STRUCTURAL WATERPROOFING

THE TRUS-CON LABORATORIES

WATERPROOFINGS - DAMPPROOFINGS
TECHNICAL PAINTS

DETROIT, MICHIGAN, U. S. A.

STRUCTURAL

WATERPROOFING

A Description of Trus-Con Waterproofing Paste, ***Concentrated,*** with Full Directions and Specifications for its Use and also Articles by Well-Known Authorities Upon the Uses and Applications of Integral Waterproofing Compounds

The Trus-Con Laboratories

Waterproofings *Dampproofings* *Technical Coatings*

DETROIT, MICHIGAN, U. S. A.

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THE rapid development of concrete construction in recent years has brought many new problems, which have engaged the earnest attention of engineers and scientists. One of the most important of these has resulted from the necessity of protecting concrete construction against the injurious action of water.

The penetration of water into concrete must in many cases be guarded against by effective waterproofing. The protective methods fall into two classes. The integral method provides for the thorough waterproofing of the whole body of concrete or plaster treated. The membrane method provides for an exterior coating of fabric, paper, felt, etc., coated with tar or asphalt; because of its cost and difficult maintenance this method, however, has become obsolete.

The problem of effective waterproofing is not simple, but many-sided. The product developed for this purpose must possess qualities that make it not only positive in results but otherwise adapted for general use in construction.

It should be very simple to use. It ought readily to mix with water as water must be its distributer. It should be so economical as to permit of general use. Its effect must be permanent. Finally, it must be of such a chemical composition that the strength of the finished structure shall not be one particle lessened but if possible increased.

TRUS-CON Waterproofing Paste, Concentrated, is the one product which effectively meets all of these requirements. Developed by many years of experiment and now tested and proved by successful use in thousands of structures, it is recognized by engineers as the one standard product for waterproofing by the integral method.

The following pages set forth the nature and qualities of TRUS-CON Waterproofing Paste, Concentrated, and serve to explain the extraordinary success this product has gained.

Discussion of Trus-Con Waterproofing Paste, *Concentrated*

The Trus-Con Laboratories, Research and Experimental Section

Simple to Use

The method of using TRUS-CON Waterproofing Paste, *Concentrated*, is the simplest possible. All that is required is to add this Paste to the water which is used to temper the dry mixture of cement, sand, stone, etc. No other method is so easy, rapid and convenient.

When powder compounds are used for waterproofing they must be mixed with the dry cement. This operation involves considerable delay, as well as extra labor cost. By the TRUS-CON method there is no hindrance to rapid, economical work.

Readily Mixed With the Gauging Water

Because it comes in paste form, TRUS-CON Waterproofing Paste, *Concentrated*, mixes very readily with water, forming a milk-like solution. It distributes itself evenly throughout the water and hence is carried uniformly to every part of the mortar or concrete.

To produce a perfect mixture between ordinary oils and water is of course impossible. It is for this reason that most of the dry powders offered for waterproofing purposes are more or less inefficient, for they consist of chemically insoluble soaps with hydrated lime, and such metallic salts of fatty acids, as is well known, are naturally repellent to water. Consequently, these waterproofing compounds do not become evenly distributed throughout the concrete and thus they cannot fulfill their purpose of waterproofing it. This result comes partly because of the difficulty of mixing such dry compounds with the cement. However, even were a perfect mixture obtainable, nevertheless the waterproofing compounds, being lighter than the cement, sand, etc., naturally float toward the top of the mixture as soon as the water is added.

The use of a dry powder for waterproofing purposes involves a difficulty such as would follow an attempt to evenly mix and hold in distribution finely pulverized cork. It is obvious that when the mass is very heavy and dry the cork is entrapped and mechanically held, but as soon as any fluidity is produced, as by the addition of water, the cork, due to its repellent nature, naturally works itself to the top of the mass, entirely destroying the original distribution.

Because TRUS-CON Waterproofing Paste, *Concentrated*, readily mixes with the gauging water and thus becomes evenly distributed throughout the concrete, its waterproofing qualities safeguard every part of the concrete. There can be no weak spots where leaks may develop. Moreover, its protection against water does not weaken with age but on the contrary becomes stronger.

Most Economical Waterproofing Compound

A lower cost results from the use of TRUS-CON Waterproofing Paste, *Concentrated*, than with any other integral waterproofing treatment. This is the case because of the concentrated nature of the Paste and because it contains no fillers like hydrated lime, clay, silica, etc., which increase the bulk of many other waterproofing compounds without raising their efficiency. In TRUS-CON Waterproofing Paste, *Concentrated*, only materials of the greatest waterproofing value are used; and hence this product, even though its cost were considerably higher, would remain the most economical to use.

The Trus-Con Laboratories, Physical Testing Division

The wide recognition of TRUS-CON Waterproofing Paste, *Concentrated*, as the standard product for the integral method of waterproofing, has come because it combines the qualities of simplicity and efficiency, together with the lowest unit of cost. Thus, TRUS-CON Waterproofing Paste, *Concentrated*, has brought about the more general use of waterproofing in concrete. Because of its low cost its use has extended, not only to structures where waterproofing was absolutely essential, but also to work where waterproofing was merely desirable.

The Bevis Hill Reservoir, Schenectady, N. Y.—Capacity 20,000,000 Gallons
C. C. McWilliams, Supt. Bureau of Water, City of Schenectady
Concrete Waterproofed with Trus-Con Waterproofing Paste, *Concentrated*

Colloidal in Composition

Portland cement mortar, as is well known, is partly waterproof. This results because of a jelly-like or colloidal substance in the cement, which tends to fill up the pores. TRUS-CON Waterproofing Paste, *Concentrated*, is itself colloidal in nature; hence it completes the waterproofing tendency of the cement by entirely filling the pores in the mortar or concrete. It thus protects fully against the softening tendency of water and does this not only efficiently but permanently.

Careful study of those chemical and physical processes which take place when Portland cement is mixed with water has made it evident that to give satisfactory results a waterproofing compound must necessarily be of a colloidal nature. The process of setting and hardening of Portland cement mortar and concrete is not alone a process of solution, hydration and recrystallization, but is supplemented by the formation of a colloidal substance which surrounds and protects the crystals of cement that bind the particles of sand and stone together.

Rochester Sewage Disposal Plant,
Department of Engineering, City of Rochester, Engineers
C. Arthur Poole, Supervising Engineer
Concrete Waterproofed with Trus-Con Waterproofing Paste, *Concentrated*

The partial degree of waterproofness which is characteristic of Portland cement mortar and concrete is due entirely to the presence of its colloidal constituent. In its absence there would be no medium to protect the crystallization against the action of water which would tend to gradually soften, dissolve and disintegrate the mass when subjected to actual practical exposure.

This colloidal substance, however, is never formed in sufficient quantity to entirely fill out all the voids in the mass, and it is accordingly the function of an efficient integral waterproofing no only to intensify the formation of the colloid originating from the cement itself, but to add a sufficient quantity of colloid so as to fill out the voids and impart to the concrete sufficient density to render it absolutely impermeable.

It is a further essential of an efficient integral waterproofing that the body not only be originally colloidal, but have the property of indefinitely retaining its colloidal development. Such absorbent colloids as clay, hydrated lime, aluminum hydroxide, etc., which have been used with very questionable success, have been found in time to dehydrate, losing their colloidal development, and are very slow and inactive in reverting to the colloidal condition. This behavior undoubtedly explains the very inconsistent results obtained with products of this character, as in some cases where conditions are particularly favorable for maintaining the colloidal condition, results will be quite satisfactory, but generally where there is any opportunity for the drying out of the colloid, the waterproofness is destroyed.

Howe & Rogers Building, Rochester, N. Y.
Crandell & Strobel, Architects
Trus-Con Waterproofing Paste, *Concentrated*, used to Waterproof all Concrete Work

Not Weakening the Concrete

The strength of concrete ought not, of course, to be sacrificed for waterproofness. The favor with which TRUS-CON Waterproofing Paste, *Concentrated*, has always been received by engineers, follows partly because, far from reducing the strength of concrete, this product enhances and maintains it. It does so because, as already explained, it protects the concrete against the disintegrating action of water.

Compounds containing large percentages of free fats, soluble soaps, active silicic acid, etc., invariably reduce the strength of concrete materially, for these products react seriously with the constituents of the cement and interfere with the normal process of hardening that is essential to develop the full strength.

A Record of Success

Even at its introduction TRUS-CON Waterproofing Paste, *Concentrated*, was recognized as possessing qualities that should make it most efficient and satisfactory. Now that its success has been demonstrated in a practical way by its use in great numbers of important and extensive operations, its reliability has become a matter of general recognition among engineers and contractors. The range of work upon which it has been used is consequently very wide; indeed, it embraces practically the entire field of concrete construction, including foundations, dams, tunnels, reservoirs, tanks, floors and all similar structures. The illustrations and letters in this book refer to a few examples of these uses.

The simple method of employing TRUS-CON Waterproofing Paste, *Concentarted*, is defined on succeeding pages in the form of general specifications. Upon request special specifications will be furnished showing in detail the method of using this product in the case of any unusual waterproofing problem.

Directions For Using TRUS-CON Waterproofing Paste—*Concentrated*

Only ordinary care and reasonable attention are necessary to obtain the very best results with this product.

In the general integral waterproofing of mass concrete, TRUS-CON Waterproofing Paste, *Concentrated*, should be employed in the proportion of one (1) part of Paste to thirty-six (36) parts of water, which provides the most economical waterproofing available.

For conditions that are particularly extreme, due to small mass or especially high pressure, the *Concentrated* Paste should be used in the proportion of one (1) part of Paste to twenty-four (24) parts of water, but under average conditions of waterproofing the Paste can be employed in the proportion of one to thirty-six (1:36) as recommended above.

Notre Dame Cathedral, New York City
Cross & Cross, Architects
Waterproofing & Construction Co., Waterproofing Contractors.
Trus-Con Waterproofing Paste, *Concentrated*, used to Waterproof Concrete Work

For a waterproofed cement plaster coat, the *Concentrated* Paste should be employed in the proportion of one (1) part of Paste to eighteen (18) parts of water.

The best results are obtained by thoroughly mixing one part Paste with an equal volume of water and while stirring vigorously add sufficient more volumes of water to give proportions required above.

The milky solution resulting from the mixture of Paste and water in the above proportion should be used in place of clear water to temper the dry mixture of cement and aggregate.

In case the mixture of Paste and water is allowed to stand for any interval between using, it should be most thoroughly stirred to insure an even and uniform solution each time just before using. The Paste diffuses so readily that this imposes no additional trouble, as very little agitation will insure its perfect distribution.

The following table gives the quantities of cement, sand and TRUS-CON Waterproofing Paste, *Concentrated,* required for a 1:2 waterproofed plaster coat to cover 100 square feet of surface.

Proportions	Thickness	Bbls. Cement	Cu. yds. Sand	Pounds Paste
1 part Cement	1"	1.00	.28	7.5
2 parts Sand	3/4"	0.75	.21	5.6
Area 100 sq. ft.	1/2"	0.50	.14	3.75

Bangor, Me. High School
Architects, Peabody & Stearns. Contractors, George H. Wilbur & Sons
Difficult Leakage Remedied by Trus-Con Paste, *Concentrated*

Cornell Stadium
Gibb & Waltz, Architects
Trus-Con Waterproofing Paste, *Concentrated*, used throughout all Concrete

TRUS-CON Service

Waterproofing and dampproofing problems have been the province of The TRUS-CON Laboratories for many years. Its organization includes a corps of expert chemists and chemical engineers, whose advice upon special problems in this field is at your disposal. This service is without charge or obligation—do not hesitate to avail yourself of it at any time.

STOPS STUBBORN LEAKAGE

Bangor, Maine, November 17 1914.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

In justice to your product, Trus-Con Waterproofing Paste, we wish to say that in the new Bangor High School we met with a particularly stubborn leakage in the basement and, after some deliberation on the part of the School Board and our firm, we concluded to use your product, namely, the Trus-Con Waterproofing Paste, and proceeded to use the same as per your instructions. The floors of the two rooms which we waterproofed had been finished, but we simply went over them with your Waterproofing Paste in a plaster coat one inch (1") thick and continued same up the walls to a ground two feet (2') above same, and on completion of this work had it absolutely waterproof.

We do not know that there is anything more to say in regard to this work, but we wish to further add that on the writer's own residence in Old Town, Maine, he has used this Paste in his stucco work on the second story, which has proved absolutely waterproof and, after several driving storms, south and east, there are no indications of any dampness whatever. Further along he used your "Stone-Tex" on his outside veranda floor, and after using only one coat the waterproofing is absolutely perfect, draining everything to the outlet.

If there is anything more we can say in regard to our highest approval of your products, we will be only too pleased to do so.

Yours very truly,

GEORGE H. WILBUR & SONS

Municipal Reservoir, Asheville, N. C.
Thoroughly and Permanently Waterproofed with
Trus-Con Waterproofing Paste, *Concentrated*

A CONVINCING REPORT

Asheville, N. C., October 15, 1910.

The Trus-Con Laboratories,
Detroit, Mich.

This reinforced concrete reservoir, built to insure an auxiliary or emergency supply for the water system of Asheville, N. C., has a capacity of 5,000,000 gallons of water. The reservoir is 150 feet in diameter at the bottom and is 40 feet deep. The wall is three and one-half feet thick at the bottom and tapers to a thickness of eight inches at the top.

As originally constructed the reservoir was not satisfactory, but has been brought to stand a thorough test and has just been accepted by the city after additional work, which was done by Mr. George H. Davidson, a contractor of Asheville. The bottom of the tank, when Mr. Davidson began work on it, was from two to six inches thick with concrete filling up the crevices and the entire floor of the tank was cracked very badly. The sides of the tank were originally built in five-foot sections, and at these seams there was a constant leakage. At some places there were cracks up and down the wall, while nearly all of the wall was porous and water seeped through. Mr. Davidson broke out all of the old bottom entirely around for a distance of two feet from the wall, going down to solid rock and cleaning out all cracks and crevices. He then filled all with good concrete mixed with TRUS-CON Waterproofing Paste to the level of the old floor. On top of this he laid the 8-inch floor with ½-inch reinforcing steel, filled with TRUS-CON Waterproofing Paste and concrete as per TRUS-CON specifications, using fifteen barrels of the Paste in the bottom. He then cut out all joints on the wall and filled them with cement mortar mixed with TRUS-CON Waterproofing Paste.

Mr. Davidson's contract was 'no pay if not water-tight' after a test of 90 days with reservoir full of water; and at the end of 90 days the mayor and five aldermen examined the reservoir and found that he had complied with his contract and made good. Quite a number of outside firms made bids for waterproofing of this reservoir, the lowest bid of these being in the neighborhood of $20,000, while the cost under Mr. Davidson's plan was $11,400, and he made some money. A number of firms making waterproofing material solicited this business but after demonstrations and examining the merits of the various waterproof materials, Mr. Davidson told me that he had decided tha TRUS-CON Waterproofing Paste was the best material to use; and he used it and made good.

N. BUCKNER,
Secretary Asheville Board of Trade.

TWO YEARS LATER

Asheville, N. C., December 14, 1912.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

Referring to your booklet, "Science and Practice in Waterproofing," in which you show an illustration of the Asheville Auxiliary Reservoir with description of its repairs made by the writer.

It gives me pleasure to state that this tank is still in good shape, and I am sending you under separate cover a new picture, which was made about two or three weeks ago.

Yours very truly,
N. BUCKNER, Secretary.

FOUR YEARS LATER

Asheville, N. C., March 20, 1914.

The Trus-Con Laboratories,
Detroit, Mich.

Your telegrams received. I have sent the following message today: "Our big auxiliary concrete reservoir water-tighted in nineteen ten with TRUS-CON Waterproofing Paste by Geo. H. Davidson, a local contractor, has been and is now satisfactory. Prior to that time, could not be used."

N. BUCKNER,
Secretary Asheville Board of Trade.

SOHO PUBLIC BATHS
2410 Fifth Avenue, Pittsburgh, Pa.

The Trus-Con Laboratories,
Detroit, Mich.

January 31, 1912.

Dear Sirs:

Regrading the waterproofing of the Soho Baths with your TRUS-CON Paste, will say that the same is perfectly satisfactory.

Our condition was rather extreme; the building is situated on Fifth Avenue, 3 stories above and 3 stories below Fifth Avenue. Our front wall extends down 36 feet below the street, being 12½ feet thick at the bottom, composed of concrete.

The water backed up against the wall from springs in the hill and came through a dozen different places, running continually at all seasons of the year at 100 gallons per hour. By applying a plaster coat ¾-inch thick 1:2, mixing the TRUS-CON Paste to the water, we have secured a water-tight job and our walls are now perfectly dry, enabling us to utilize the floors below Fifth Avenue and make a swimming pool in which we have used the TRUS-CON Paste with satisfaction.

The walls were so dry that the carpenter, thinking there was no water back, drilled through the plaster coat to fasten partition, when instantly the water gushed forth in a stream with much pressure, proving conclusively that your material is a thorough waterproof, and we will always use it in our waterproofing.

Yours truly,
D. P. MARSHALL,
Superintendent.

Pittsburgh, Pa., March 20, 1914.

The Trus-Con Laboratories,
Detroit, Mich.

At Mr. Mackin's request I send you my best indorsement of TRUS-CON Waterproofing Paste. We had an almost impossible job successfully treated with this material. Conditions too extreme to go into details. Using nothing else now.

D. P. MARSHALL, Supt.,
Soho Public Baths, City of Pittsburgh.

Swimming Pool, Soho Public Baths, Pittsburgh, Pa.
Trus-Con Waterproofing Paste, *Concentrated*, Remedies a Seemingly Impossible Condition

ARTHUR L. PILLSBURY, ARCHITECT

Bloomington, Ill.

The Trus-Con Laboratories,
Detroit, Mich.

Your shipment of TRUS-CON Waterproofing Paste duly received and have used with what seems to be good results.

We have also instructed the Davis Ewing Concrete Company to use this material on some floor work which they have for a client of mine, and I think it is going to give just the satisfaction that we want

Yours sincerely,
ARTHUR L. PILLSBURY.

JAMES KENNEDY CONSTRUCTION COMPANY

Portland, Oregon, Feb. 9, 1915.

The Trus-Con Laboratories,
Detroit, Mich.

Replying to your inquiry with reference to our use of Trus-Con Waterproofing material. We used your material last year in the construction of six reservoirs: Two at Linnton, two at Willbridge, and two at Whitwood Court. The Waterproofing proved to be satisfactory in every way, as the city test showed no leaks through the concrete. The engineer on this work was Mr. L. C. Kelsey, Selling Building, Portland, Oregon. He can certify to the truth of this statement, as he was present and in charge of the city when the tests were made.

Yours truly,
JAMES KENNEDY CONSTRUCTION CO.
By J. D. Hanley.

THE FAIRMONT CREAMERY COMPANY
Columbus, Ohio

The Trus-Con Laboratories,
Detroit, Mich.

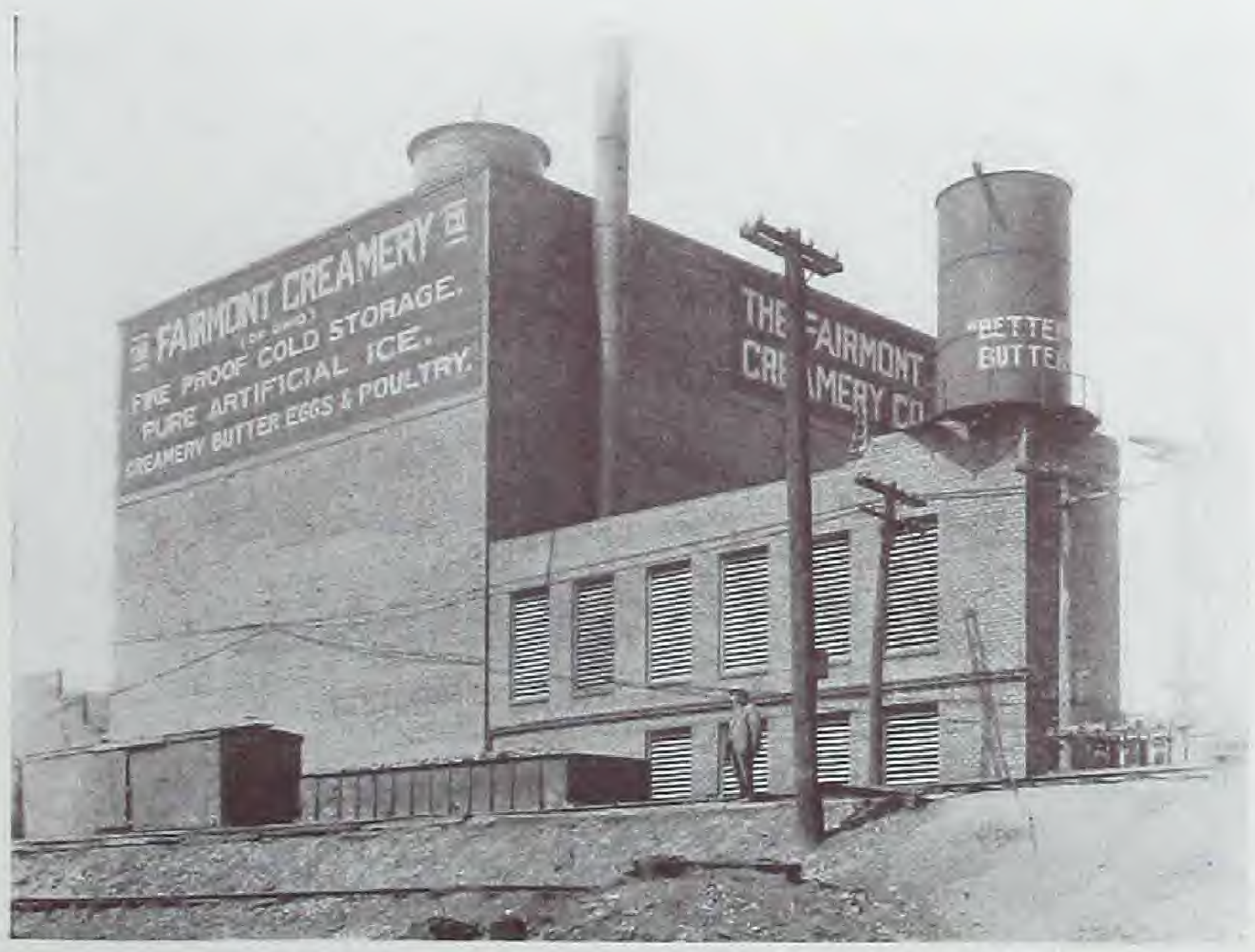
May 1st, 1914.

Referring to your inquiry as to whether we were pleased with Trus-Con Waterproofing Paste Concentrated which we used on all floors of our new building in Columbus, where water was freely used, will say that we found it very satisfactory.

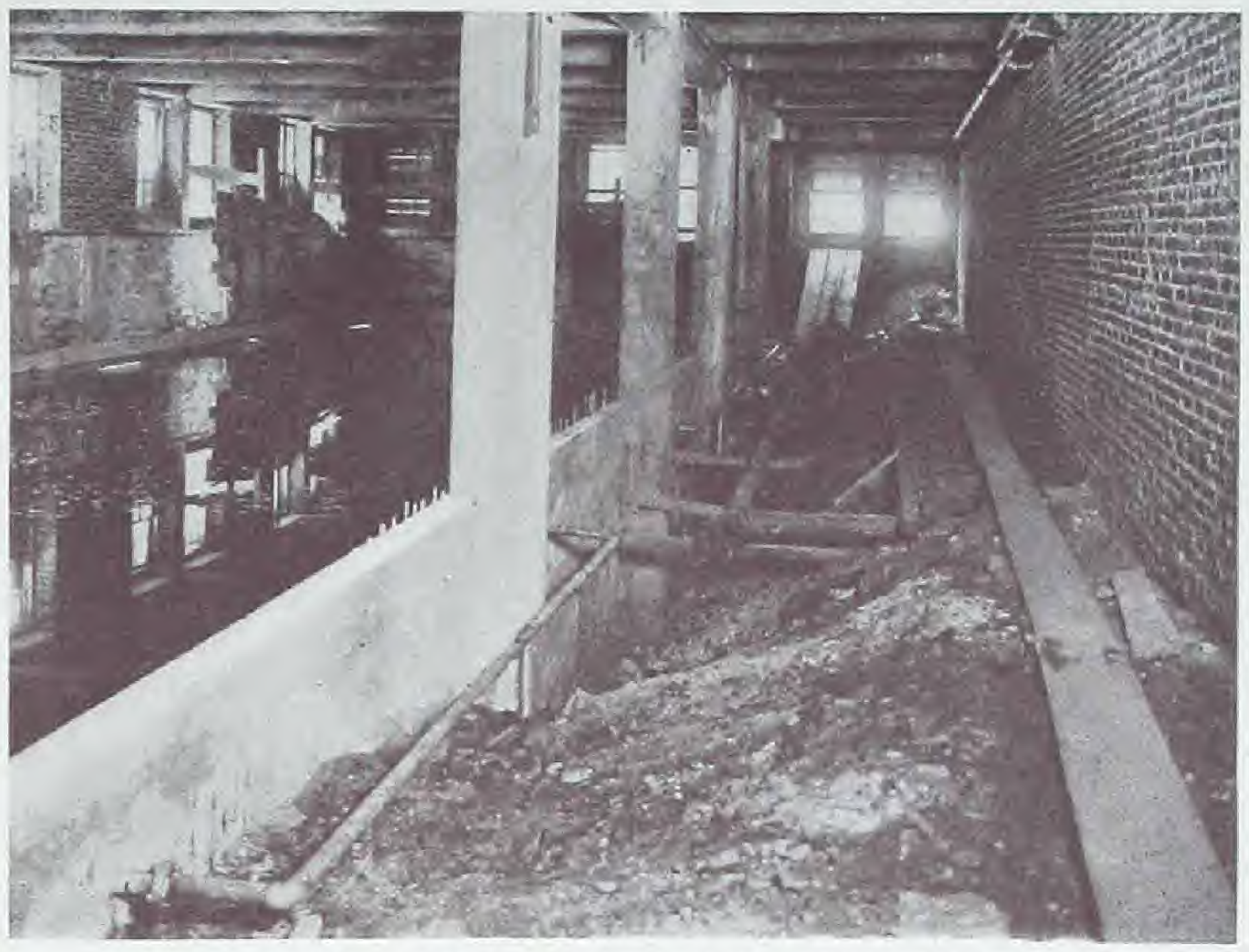
We put six inches of concrete and one inch of topping on these floors and we used the Paste in both. We have never had any trouble with the water soaking through, and in fact we are so well pleased with this material that we used it on some concrete floors which were placed upon wooden floors in a building we fitted up for a creamery at Buffalo, N. Y. So far, in the latter building, we have seen no leaks through this material.

As far as we can see, and we have given it an eight months' test in Columbus, this material gives perfect satisfaction.

Yours truly,
THE FAIRMONT CREAMERY COMPANY,
By M. H. Bennett, Construction Manager.



The Fairmont Creamery Co., Columbus, Ohio
Floors Waterproofed with Trus-Con Waterproofing Paste, *Concentrated*



Swimming Pool, Y. W. C. A. Building, Philadelphia, Pa.
Hewitt & Granger, Architects. Charles Gilpin, General Contractor
Effectively Waterproofed with Trus-Con Paste, *Concentrated*

CONSTRUCTION SUPERINTENDENT WELL PLEASED

Philadelphia, Pa., July 31, 1915.

The Trus-Con Laboratories,
Detroit, Mich.

Regarding the use of Trus-Con Waterproofing Paste in the swimming pool of the Y. W. C. A. Building, would say that I have found it very satisfactory indeed.

The pool is 4 feet deep at the shallow and 9 feet 6 inches at the deep portion. It is 20 feet wide and 60 feet long. The walls are 10 inches thick with a 10 inch bottom. We used a 1:2:4 mix with 24 parts of water to every one part of your Waterproofing Paste.

We stripped the outside of the pool the day after pouring, to allow the air to get to it and to see if there were any voids. In a week, we stripped the inside of the pool and cleaned it thoroughly. We then allowed it to stand for one week. Following this we filled it half full of water, allowing it to stand thus for a week, then filling it to overflow, and leaving the pool standing full of water.

We found the pool absolutely water-tight, with the exception of where the feed water pipes and over-flows passed through the wall. Underneath these pipes, there were several small leaks, caused by shrinkage of the concrete. After pumping the pool, we stopped the leaks by cutting around the pipes about two inches, and taking strings of oakum soaked in Trus-Con Plaster Bond, and caulking tightly. We then cemented over these places with a 1:1 mix using 18 parts of water to one part of Waterproofing Paste.

I cannot speak too highly of Trus-Con Waterproofing Paste. If conditions are thoroughly examined, and the Paste used according to directions, an absolutely watertight job will be obtained.

Yours truly,
W. HARVEY, Supt. of Construction.

PACIFIC ELECTRIC ENGINEERING COMPANY

Portland, Oregon.

The Trus-Con Laboratories,
Detroit, Mich.

In answer to your inquiry of recent date, we beg to say that we used eighty gallons of TRUS-CON Waterproofing Paste last February in the floors and walls of the machinery pit of the power house erected by us at Oswego for the Oregon Iron and Steel Co.

After the pit walls were completed and before the cement had time to fairly set, an accident occurred at the headgates which caused the water to stand in the pit about three feet deep for a week. During this time the walls showed no leakage and we are thoroughly convinced that you have an article that will water-proof any cement that it is applied to.

Should we need any in the future you may rest assured that you will hear from us.

Yours very truly,
PACIFIC ELECTRIC ENGINEERING CO

Moffett & Sons, Wholesale Grocers, Flint, Mich.
Another Story Added to this Building through the use of Trus-Con Waterproofing Paste, *Concentrated*

MOFFETT & SONS
Wholesale Grocers

Flint, Mich., May 27, 1913.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

Last summer, as you are aware, we erected a building in this city for the accommodation of our Wholesale Grocery Business. The location on which we erected this building—while ideal from a distributive point of view, being in the heart of the business district—is near the river and the floor of our basement being necessarily several feet below the level of the river, caused us considerable anxiety as to the results of our efforts to insure a dry basement. We had previously received through the mail some of your printed matter relating to TRUS-CON Waterproofing Paste, and having faith in your statement that this paste would actually make concrete mixture waterproof, we purchased enough to cover the necessary requirements for waterproofing the basement floor and walls to a height of one foot above the ground level. We used this paste strictly in accordance with your instructions, and it affords us pleasure to assure you that the results are most gratifying, for notwithstanding the fact that our building stands on porous ground and sandy soil, and as before stated the basement floor is lower than the level of the river, we have an absolutely dry basement, which means to us another story added to our building, which we believe would not have been possible were it not for the fact that we used your TRUS-CON Waterproofing Paste in our concrete mixture.

We are building another block of two stores this summer in a similar location and have specified that TRUS-CON Waterproofing Paste must be used in floor and wall construction.

Assuming that the foregoing information may be of interest to you, we are
Cordially,

MOFFETT & SONS.

GLENMORE DISTILLERIES COMPANY

Owensboro, Ky., Nov. 10, 1911.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

Regarding the use of TRUS-CON Waterproofing Paste for the construction of tanks and cisterns, we are pleased to advise that last summer we constructed a beer well 16 feet in diameter by 12 feet deep, using a 1-2-4 mix of washed gravel concrete, and mixing this with TRUS-CON Waterproofing Paste as per your standard specifications.

Two days after this beer well was poured it was surrounded with water to within one foot of the top, but so far we have yet to see the slightest sign of seepage, and it is apparently absolutely water-tight.

Yours very truly,

GLENMORE DISTILLERIES COMPANY.
By H. S. Barton, V. P. and Gen. Mgr

THE LEHIGH COAL & NAVIGATION CO.
Bangor, Maine

Bangor, Me., October 23, 1913

Messrs. N. H. Bragg & Sons,
City

Gentlemen:

have refrained from reporting the results of our water-proofing until the TRUS-CON work had adequate water-resisting tests. The last three weeks of rain have afforded us satisfactory demonstration of the goodness of TRUS-CON.

Our pocket is erected over a tunnel, about 150 x 8 x 8, and beneath the tunnel is a subterranean river, icy-cold, with swift current. At far end of tunnel, a ledge retarded egress of water, down the general gently sloping tract on which the pocket is built. The tunnel was well built, the action of the river, and boiling springs nearly broke its back, despite the several thousand tons of dead-weight. The floor and both sides of the tunnel opened, and through the fissures poured the water, at times. An endless carrier with several hundred balancing buckets runs in the tunnel through ends and across top of pocket.

Frequently, upon starting work for the day, and particularly in winter, we would find a seepage during the night of about 30,000 to 35,000 gallons of crystal, cold water in the tunnel submerging the buckets. In zero weather, the attendant ice was costly and annoying, to put it mildly.

The combined efforts of rotary pump and six-inch drain leading from far end of tunnel failed to carry off the water at all times.

We had the tunnel water-proofed two years ago, and for a time it held. Although at no time did this repaired tunnel have so long a siege of rain, feeding the river and springs, it eventually broke under strain less severe than to which subjected since October 1.

Finally, we evolved a new plan.

We dug auxiliary side drains, giving total drainage length of about 3,000 feet, blasted the ledge, and then having, as we believe, diverted the water in a measure, we followed your TRUS-CON book to the letter, and used that wonderful compound in repairing and waterproofing the great fissures in our heavy concrete tunnel floor and walls.

The work was performed under great difficulties, as water constantly was bubbling up in the tunnel, although diminished in a measure by the new drains. The concrete mixture with TRUS-CON in it hardened in the water, and it was remarkable to note its stiffening propensities under circumstances that would simply wash away ordinary concrete as fast as placed in position.

TRUS-CON, we believe, has solved our costly, vexatious and at times baffling problem. I might add that the cost of the water-proofing did not exceed $25, although several thousands had been expended previously in the attempt to overcome the trouble. We will gladly impart personal information, and exhibit the work to any others annoyed by similar troubles, and show them how to overcome them with TRUS-CON Waterproofing Paste, Concentrated, properly applied.

Very truly yours,

J. McLEOD, Agent.

Smithfield Street Public Comfort Station, Pittsburgh
J. P. Brennan, Architect
Trus-Con Waterproofing Paste, *Concentrated*, used throughout all Concrete

HARDY & ARONS
Dayton, Ohio

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

Ever since the erection of the Colonial Building, corner of Third and Grimes streets, the basement has been useless because of the great seepage of water through the walls and cement floor.

We contracted with the Dayton Fiber Plaster Co., of this city, to make this basement watertight and dampproof with your products. They applied a $\frac{3}{4}$-inch coating of cement mortar on these walls and a 2-inch cement floor, using your Waterproofing Paste in the water with which the material was mixed. The surface thus treated amounted to about 10,000 square feet. Our basement is now absolutely dry, and we cannot too highly recommend your products.

Respectfully yours,
HARDY & ARONS.

H. B. NELSON & SONS
Contractors

Muskogee, Okla., June 25, 1914.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

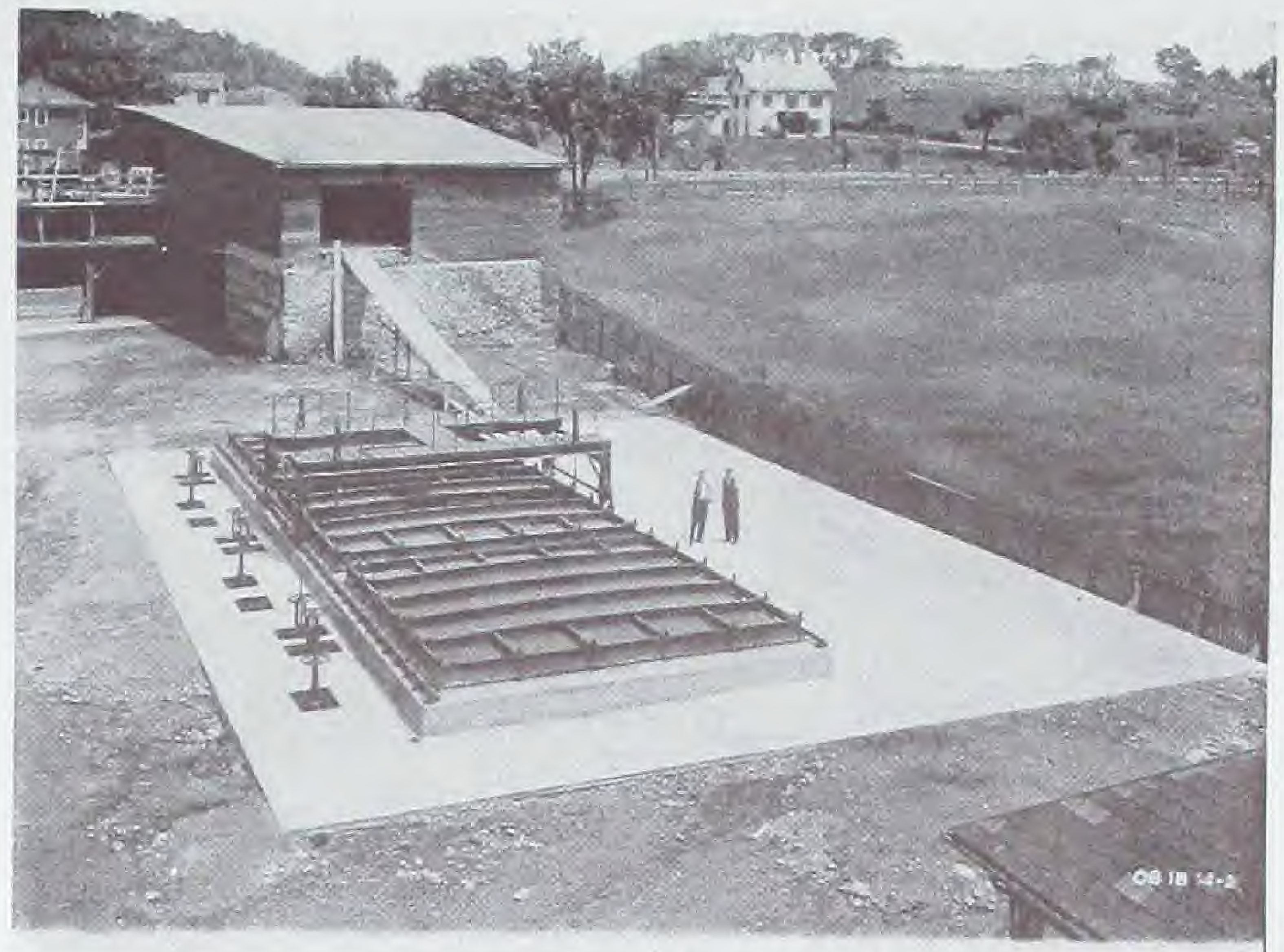
In March, 1913, we finished the Agency Hill Reservoir for the City of Muskogee and waterproofed this 6,000,000 gallon reservoir with Trus-Con Waterproofing Paste. We first used the Waterproofing Paste in the construction of a small tank in which to store water for mixing concrete as the reservoir site was above the reach of city water. This tank we reinforced with woven wire and concrete of 1-2-4 mixture. We used in this the recommended mixture and this tank with three-inch walls was completely waterproof.

In constructing the large reservoir, after removing the forms and while the concrete was yet damp we put upon it a thin coating of cement made up of Waterproofing Paste diluted in water. Upon the floor of the reservoir while green we put on two heavy coats of the Waterproofing (as above mixed). In this way we closed all sand voids and overcame any unevenness in the concrete with very satisfactory results.

Our specifications permitted of not more than five gallons of seepage per minute, but when the test was made by the city for its acceptance there was only one quart seepage. The structure was thoroughly sub-drained with tile around and under the floor and any seepage there was, occurred not through the concrete but at points where the supply and delivery pipes passed through the floor. At any rate at this time, one year after completion, the seepage is practically nothing.

Yours truly,
H. B. NELSON & SONS,
By J. Perwitt Nelson

Agency Hill Reservoir, Muskogee, Okla.
H. B. Nelson and Sons, Contractors
Effectively Waterproofed with Trus-Con Waterproofing Paste. *Concentrated*



Concrete Purifying Tanks, Arlington Gas Light Co., Arlington, Mass.
Tanks made Gas Tight through use of
Trus-Con Waterproofing Paste. *Concentrated*

THE LIGHT, HEAT & POWER CORPORATION

Boston, Mass., August 11, 1914.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

Regarding your inquiry concerning the results obtained from using Trus-Con Waterproofing Paste in the reinforced concrete gas purifiers which we built recently for the Arlington Gas Light Company at Arlington, Mass., I beg to state that the paste was applied by the integral method according to your directions, and after the forms were removed the boxes were given a one-inch plaster coat inside. After being completed, these boxes were subjected to an air and gas test of one pound pressure. The concrete in two of the boxes was found to be perfectly gas tight and that of the third had one very slight leak which was stopped immediately after its location.

We are very well satisfied with the results obtained with this Paste and believe it will give satisfaction on any work of similar character.

Yours very truly,
F. E. LEARNED, Mgr.

W. H. SIEVERLING, C. E
General Contractor

Springfield, Ohio.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

Regarding the waterproofing you furnished for the Springfield Light, Heat & Power Co.'s new consolidated power-house, will say that nearly two tons of "TRUS-CON Waterproofing Paste" were used.

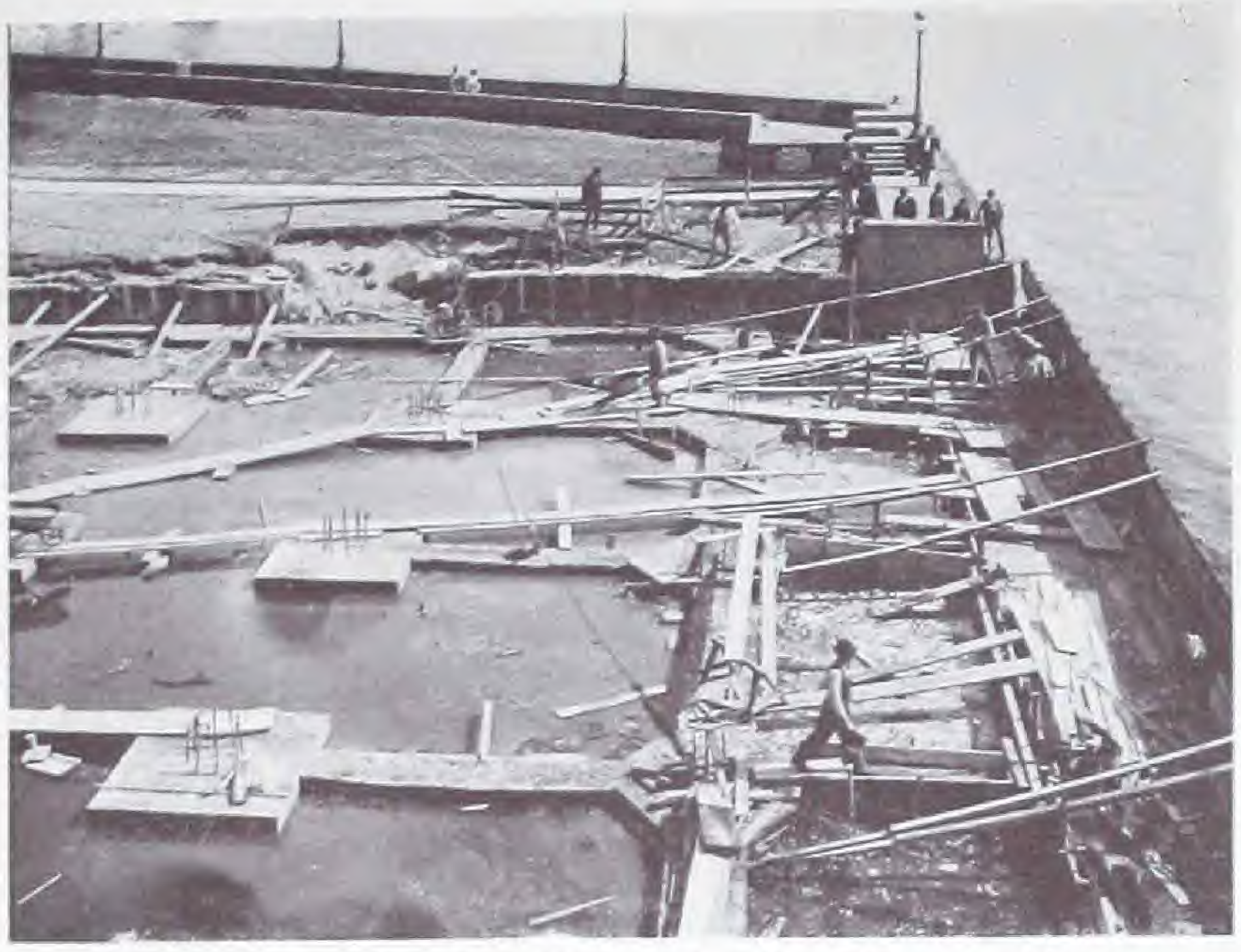
The situation seemed hopeless, as I had not only to contend with numerous living springs, flowing through the power plant, coming up from the fissures and seams of limestone cliffs out of which the foundations were blasted, but also high waters from a turbulent creek, flowing by the plant. I had as much as eight (8) feet of water in the basements about all last winter and spring.

After much pumping and building of sheep troughs and sumps, and using plenty of TRUS-CON Waterproofing Paste incorporated into the concrete for walls, floors and top coat, I succeeded in getting a perfectly dry basement for their electrical machinery.

I like to use TRUS-CON Paste, because with the average common labor you can get, it is easier to use and get results than with any other waterproofing that requires intelligent, if not expert, manipulation.

I can assure you that the Light Company is more than satisfied, as we have had some high waters since, and everything proved water-tight.

Very truly,
W. H. SIEVERLING.



The Gowan-Lenning-Brown Building, Duluth, Minn.
F. G. German, Architect. Leif Jenssen, Assistant Architect.
W. J. Zitterell, Contractor
Basements Waterproofed against heavy hydrostatic pressure with Trus-Con Waterproofing Paste, *Concentrated*

R. D. BURNETT CIGAR COMPANY

Birmingham, Ala., June 12, 1913.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

Regarding your inquiry as to the results obtained through the waterproofing of the basement in our Wholesale Cigar House, part of which is also used for Retail and Wholesale Piano Store purposes; wish to state that through the directions of the architect for this building, Mr. H. B. Wheelock, this city, we bought of you about 1500 pounds of the TRUS-CON Waterproofing Paste, as manufactured by THE TRUS-CON LABORATORIES, and used same on the work with the best results. The basement, even after the concrete base of the floor and the concrete walls were poured, was certainly in very bad condition owing to the great amount of water which ran everywhere through the concrete. As I understand, the Waterproofing Paste was used in the 1-inch cement finish of the floors and in the ¾-inch cement coat applied to all the basement walls, and as we had a very competent man direct the application of the cement finish, we were very successful indeed in getting an absolutely water-tight job, in spite of the pressure under which the water seemed to come through the concrete previous to the time of applying the cement finish.

Since the work has been completed, about four months ago, we have had some very hot weather, but so far have not had any signs of defective work or defects due to the material in any part of the basement. The goods stored in the basement require absolutely dry storage space as even a slight dampness would affect them seriously, and we can only say that we have no trouble whatever on account of dampness or wet spots in floor or walls.

We, therefore, take occasion to state that we can unhesitatingly recommend the use of this material for waterproofing purposes, under severe conditions, as we certainly had bad conditions before the work was waterproofed and had all kinds of water in the basement. You are at perfect liberty to use this letter in any way that will help you to bring this excellent material before the trade.

Very truly yours,
R. D. BURNETT CIGAR COMPANY,
Per R. D. Burnett, Pres.

F. B. HATCH
Contractor and Builder

San Juan, Porto Rico, January 20, 1914.

Messrs. Behn Bros., San Juan, P. R.

Gentlemen:

I take pleasure in stating that I have used your TRUS-CON Waterproofing Paste on several pumping pits where they had very severe test and will say that I am highly pleased with it. It is the best waterproofing for mixing with concrete that I have yet found.

Yours very truly,
F. B. HATCH

WAUKESHA CONCRETE BLOCK & MATERIAL CO.

Waukesha, Wis., July 21, 1910

The Trus-Con Laboratories,
Detroit, Mich.

We believe your TRUS-CON Waterproofing Paste to be superior to other preparations we have used.

Very truly,
WAUKESHA CON. BLOCK & MAT. CO.

BICKS & KLUNPP

The Trus-Con Laboratories,
Detroit, Mich.

Decatur, Ill., Jan. 27, 1911.

Gentlemen:

We are in the concrete business, and are making burial vaults. We are told that if we used ——— Waterproofing Powder we could make these vaults waterproof, but we find by filling the vaults with water, that they leak like sieves, and that the waterproofing powder comes up to the top as the concrete is poured. After the vaults have set, you can scrape the powder off with your finger, and it leaves the concrete full of soft places.

We do not care to risk any more labor or material with powder waterproofing, but want you to send us prices on your Waterproofing Paste. We have poured a box about 12 inches square, using TRUS-CON Waterproofing Paste, and upon filling same with water, note that the outside keeps perfectly dry. In using the powder waterproofing, we gave the same careful attention to the mixing. We first mixed the cement and waterproofing compound through a fine sieve, and made sure that the dry mixture was perfectly uniform.

Very truly yours,
BICKS & KLUNPP.

BATES MANUFACTURING CO.

Lewiston, Maine, March 20, 1914.

The Trus-Con Laboratories,
Detroit, Mich.

Gentlemen:

Your telegram of today received. We used 53 barrels of TRUS-CON Waterproofing Paste to water-proof concrete walls and floors of turbine chambers, forebay and tailrace of hydraulic power plant. Present conditions indicate perfect success.

Very respectfully,
BATES MANUFACTURING CO.

Municipal Reservoir, Daly City, Cal.
F. C. Roberts, Engineer. Tieslau Bros., Contractors
Waterproofed with Trus-Con Waterproofing Paste, *Concentrated*, in accordance with Waterproofed Cement Plaster Coat process

A Few Users of Trus-Con Waterproofing Paste, *Concentrated*

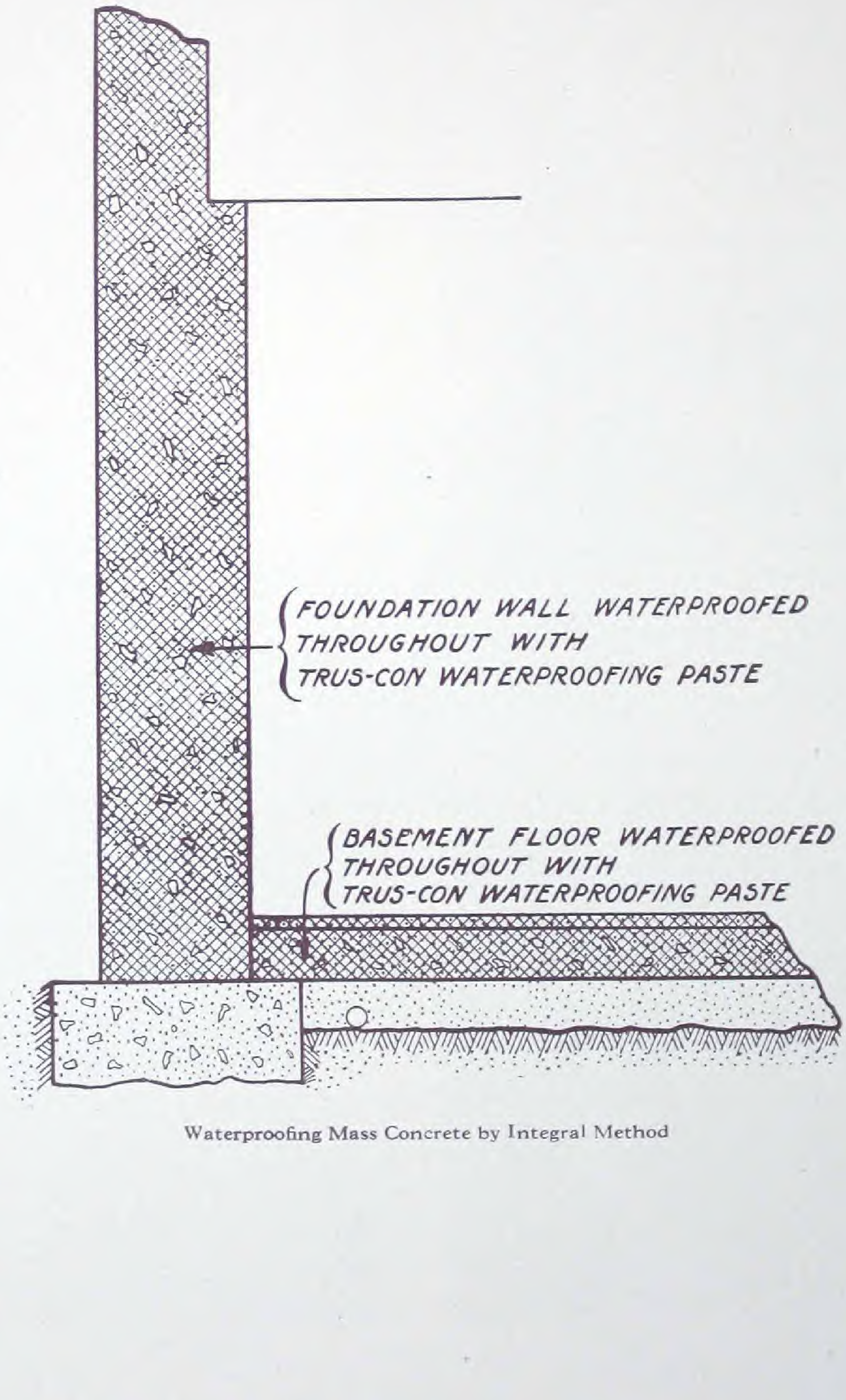
Pennsylvania Rubber Co., Jeannette, Pa.
Burroughs Adding Machine Co., Detroit, Mich.
Cadillac Motor Car Co., Detroit, Mich.
Swift & Company, South Omaha and Cambridge.
Boston & Maine Railway.
Dodge Bros., Detroit, Mich.
Sellwood Park Swimming Pool, Portland, Ore.
Water Tank, Cojimar, Cuba.
Cook Brewing Co., Evansville, Ind.
Frick & Lindsay Building, Pittsburgh, Pa.
Heider Manufacturing Co., Carroll, Iowa.
The Mission Conception, San Antonio, Texas.
Los Angeles Brewing Co., Los Angeles, Calif.
Sparta Gas & Electric Co., Sparta, Ill.
Jacksonville Concrete Co., Jacksonville, Fla.
Stitzer Engineering & Contracting Co., Philadelphia.
Turner & Stewart, Camden, N. J.
McClintic-Marshall Construction Co., Pottstown, Pa.
Atlantic City Gas Company, Atlantic City, N. J.
Bright & Co., Hazelton, Pa.
R. D. Burnett Building, Birmingham, Ala.
U. S. Glass Company, Butler, Pa.
Butler Concrete & Plaster Co., Butler, Pa.
Standard Steel Car Co., Butler, Pa.
10th Reg. Armory, Monongahela, Pa.
Moose Temple, Monnessen, Pa.
U. S. Government Experimental Mine, Wallace Sta. Pa.
U. P. Church, Erie, Pa.
St. Pius Church, McKeesport, Pa.
Duquesne Parochial Schools, Duquesne, Pa.
Pittsburgh Water Heater Co., Idlewood, Pa.
Boggs Building, Pittsburgh, Pa.
Crafton High School, Crafton, Pa.
P. & L. E. Ry.
Keystone Coal & Coke Co., Greensburg, Pa.
New Castle Dry Goods Co., New Castle, Pa.
Pittsburgh Coal Co., Pittsburgh, Pa.
Monongahela Saw & Planing Mill Co., Monongahela, Pa.
Northern Power Co., Potsdam, N. Y.
Caledonia Milling Co., Caledonia, Mich.
Henahan King Co., Toledo, Ohio.
Columbus Machine & Tool Co., Columbus, Ohio.
J. M. Wagenheim & Son, Newark, Ohio.
Herman Gundlach, Houghton, Mich.
Thomas Culinan, Providence, R. I.
Ottaray Canning Co., Ltd., Henderson, N. C.
Wayne County Farm, Eloise, Mich.
Stark Brewing Company, Canton, Ohio.
Penn Mining Co., Vulcan, Mich.
Ledbetter Manufacturing Co., Rockingham, N. C.

Morgan Engineering Co., Alliance, Ohio.
Rubber Regenerating Co., Mishawaka, Ind.
Prestolite Co., Indianapolis, Ind.
Sterling Silk Glove Co., Bangor, Pa.
Adam E. Ferguson Creamery, Lansing, Mich.
Consoilidated Gas, Electric Light & Power Co., Baltimore Md.
Bedford Foundry & Machine Co., Bedford, Ind.
Thomas Brothers, Moosejaw, Sask.
Plymouth Milling Co., Plymouth, Mich.
International Time Recording Co., Endicott, N. Y.
Dr. C. E. Schmitz, Cambridge, Idaho.
First National Bank Lestershire, N. Y.
Fonnesbeck Knitting Co. Ogden Utah.
Cheboygan Manufacturing Co. Cheboygan, Mich.
St. Louis South-Western Ry.
Albion Shale Brick Co. Albion, Ill.
Old Crow Distillery, Glenn Creek, Ky.
Packard Motor Car Co., Detroit and Philadelphia.
Medical College, Charleston, S. C.
Western Sugar Refining Co., San Francisco.
Ford Service Buildings—
Cincinnati.
Louisville.
Indianapolis.
Atlanta.
Dallas.
New York City.
Philadelphia.
Detroit.
Minneapolis.
Bates Mfg. Co., Lewiston, Me.
Oliver Chilled Plow Co., South Bend, Ind.
Stroh Brewing Company, Detroit, Mich.
Edison Illuminating Co., Detroit, Mich.
Pittsburgh Comfort Station, Pittsburgh, Pa.
Arlington Gas Co.
City Reservoir, Daly, Cal.
Atchison, Topeka & Santa Fe Ry.
Kresge Bldg., Detroit, Mich.
Hotel Statler, Detroit, Mich.
Lever Bros. Soap Co., Boston, Mass.
Thomas A. Edison, Newark, N. J.
Goodyear Rubber Company, Akron, Ohio.
Agency Hill Reservoir, Muskogee, Okla.
Grand Central Terminal, New York City, N. Y.
Hawley & Hoops Company, New York City, N. Y.
Revere Rubber Company, Chelsea, Mass.
Bath Iron Works, Bath, Maine.

Lozier Motor Car Co., Detroit, Mich.
Hudson Motor Car Co., Detroit, Mich.
Gramm Motor Car Co., Lima, Ohio.
City Reservoir, St. Charles, Mo.
City Reservoir, Hancock, Mich.
City Reservoir, Asheville, N. C.
City Reservoir, Lafayette, Ind.
Lighting Plant, Springfield, Ohio.
Mexican Light & Power Co., Mexico City, Mexico.
Westinghouse Lamp Factory, Watsessing, N. J.
Grain Elevator, Fort Worth, Texas.
General Electric Co., Schenectady, N. Y., etc.
Goldfield Milling & Transportation Co., Goldfield, Nev.
Rogers-Brown Ore Co., Deerwood, Minn.
Markham Air Rifle Co., Plymouth, Mich.
Seaboard Airline Ry., Portsmouth, Va.
Beckett Paper Co., Hamilton, Ohio.
Western Electric Co., New York City, and elsewhere
Inter-Ocean Steel Co., Chicago, Ill.
Jefferson Powder Co., Birmingham, Ala.
Chicago, Rock Island & Southern Ry.
Magee Theatre, Schenectady, N. Y.
Hartman Furniture Co., Warehouse, Chicago, Ill.
Beckwith Stove Plant, Dowagiac, Mich.
Anderson Forge Co., Detroit, Mich.
Armstrong Tannery, Detroit, Mich.
Wissmath Packing Co., Fort Madison, Ia.
Quartermaster's Department, Washington, D. C.
Kling Brewery, Detroit, Mich.
Capitol City Brewery, Montgomery, Ala.
Great Lakes Engineering Co., Ashtabula, Ohio.
Brunett Falls Mfg. Co., Cornell, Wis.
Continental Motor Mfg. Co., Detroit, Mich.
Central Market Building, Detroit, Mich.
Government Light House Caissons, Detroit River.
Pere Marquette R. R.
Grand Rapids & Indiana R. R.
Edward Ford Plate Glass Co., Rossford, Ohio.
Detroit Free Press Building, Detroit, Mich.
Shepard Building, Chicago, Ill.
Press Building, Pittsburgh, Pa.
Oil Well Supply Building, Pittsburgh, Pa.
Hamburger Building, Pittsburgh, Pa.
Y. M. C. A., Butler, Pa.
Y. M. C. A. Building, Greensburg, Pa.
Y. M. C. A. Building, New Castle, Pa.
Y. M. C. A. Swimming Pool, Red Wing, Minn.
Y. M. C. A. Swimming Pool, Fostoria, Ohio.
Y. M. C. A. Swimming Pool, St. Joseph, Mo.
Y. M. C. A. Swimming Pool, Burnham, Pa

Ford Service Building, Long Island City, N. Y.
Concrete Foundations and Floors Waterproofed with Trus-Con Waterproofing Paste *Concentrated*

Pennsylvania Mutual Building, Philadelphia, Pa.
Trus-Con Waterproofing Paste, *Concentrated*, used throughout all Concrete Work



Waterproofing Mass Concrete by Integral Method

Specifications for Waterproofing Mass Concrete by Integral Method

Applicable to Standpipes, Cisterns, Reservoirs, Foundations and Similar Structures

1. Intent—It is the intent of these specifications to obtain a water-tight concrete structure.

2. Method—Water-tightness shall be secured by the addition of TRUS-CON Waterproofing Paste, *Concentrated,* as manufactured by THE TRUS-CON LABORATORIES, Detroit, Michigan, to all water used to temper the dry mixture of cement and aggregate, in proportions and mixed as directed below.

3. Ingredients and Proportions for Concrete—The concrete composing the main body of the structure shall consist of one (1) part cement, two (2) parts of sand, and four (4) parts of stone, each to meet the following requirements:

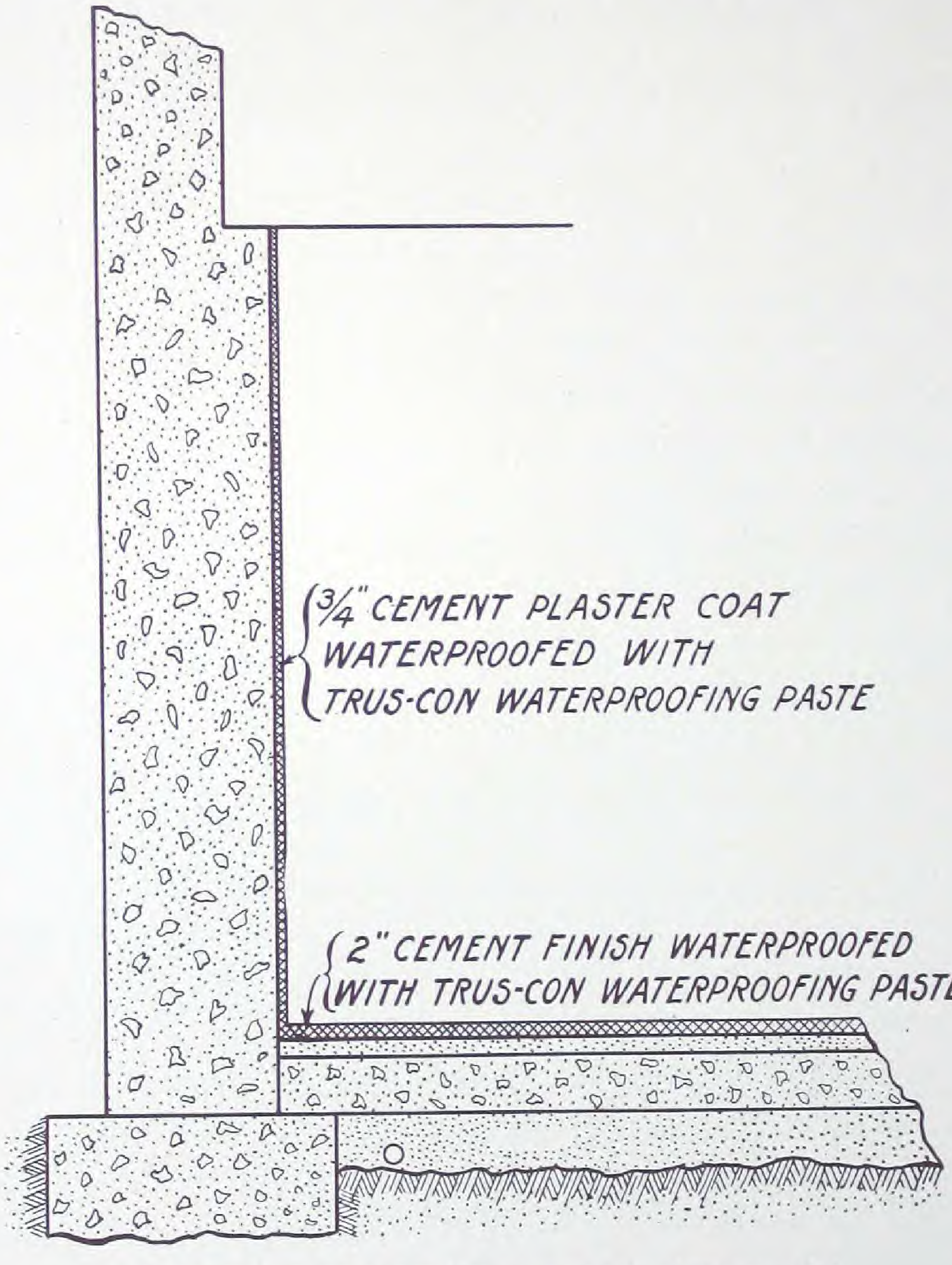
(a) The cement shall be a high grade Portland, which has been carefully tested and found to satisfactorily pass the requirements of the Standard Specifications of The American Society for Testing Materials, and preferably ground so that eighty per cent (80%) shall pass a standard two-hundred (200) mesh sieve.

(b) The sand shall consist of spherical grains of any hard rock that is practically free from clay, absolutely free from organic matter, and uniformly graded in size from coarse to fine.

(c) The stone shall be screened from gravel, and shall for sixty per cent (60%) of its bulk be uniformly graded between diameters of one (1) and one and one-half (1½") inches, and for forty per cent (40%) of its bulk be uniformly graded between diameters of one quarter (¼) and one (1) inch. A hard crushed trap rock may be substituted for gravel if screened to meet the requirements indicated.

4. Mixing—The dry mixture of cement, sand and stone in the above proportions shall be tempered to a medium wet consistency with water to which one (1) part of TRUS-CON Waterproofing Paste, *Concentrated,* has been added as directed by the manufacturers, for every thirty-six (36) parts of water.

5. Placing—All the concrete shall be placed in one continuous operation, each pouring being thoroughly spaded to insure uniform density. In cases where joints are absolutely unavoidable, very special care shall be taken to clean and roughen the old surface and have it thoroughly wet and slush-coated immediately before placing additional concrete.



Waterproofing Concrete or Masonry by Means of Waterproofed Plaster Coat Applied to Interior Surfaces

Specifications for Waterproofing Concrete and General Masonry Structures by Means of Waterproofed Plaster Coat

Applicable to Cisterns, Reservoirs, Foundations, Basements, Tunnels, Subways and Similar Structures

1. Intent—It is the intent of these specifications to obtain a water-tight structure.

2. Method—Water-tightness shall be secured by plastering the interior surface of the structure with a continuous coat of Portland cement mortar water-proofed with TRUS-CON Waterproofing Paste, *Concentrated*, as manufactured by THE TRUS-CON LABORATORIES, Detroit, Michigan.

3. Ingredients and Proportions of Waterproofed Plaster Coat—The mortar composing the plaster coat shall consist of one (1) part of cement and two (2) parts of sand, to meet the following requirements:

(a) The cement shall be a high grade Portland, which has been carefully tested and found to satisfactorily meet the requirements of the Standard Specifications of the American Society for Testing Materials and preferably ground so that eighty per cent (80%) shall pass a standard two hundred (200) mesh sieve.

(b) The sand shall consist of spherical grains of any hard rock that is practically free from clay, absolutely free from organic matter, and uniformly graded in size from coarse to fine.

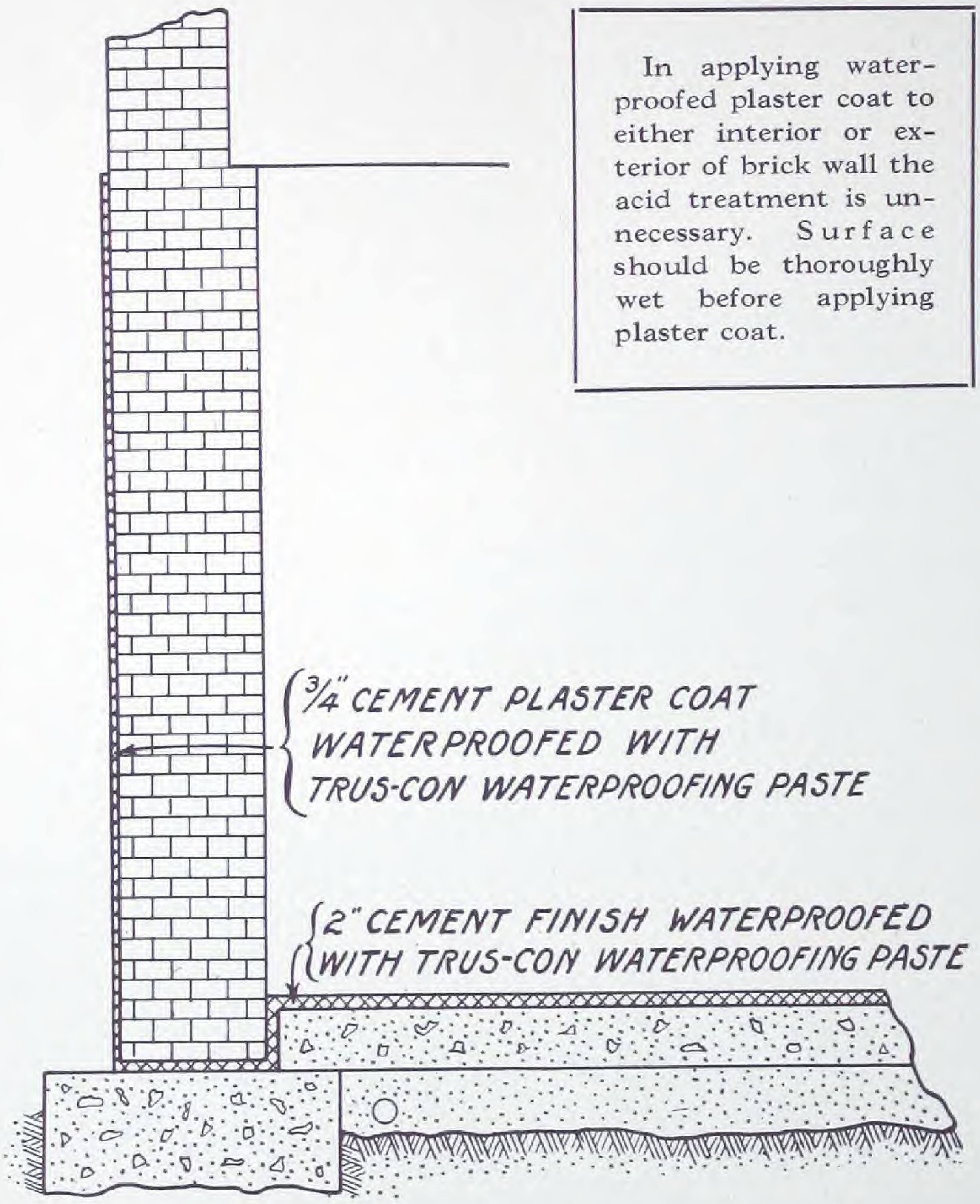
4. Preparation of the Coating—The waterproofed cement mortar shall be prepared by thoroughly tempering (to required consistency) a dry mixture of one (1) part of cement and two (2) parts of sand, with water to which TRUS-CON Waterproofing Paste, *Concentrated*, has been added in the proportion of one (1) part of Paste to eighteen (18) parts of water, as directed by the manufacturers.

5. Preparation of Surface to be Coated—Before plastering the cement mortar on the hardened concrete, the surface of same shall be treated as indicated in the following:

(a) The hardened surface shall be mechanically roughened by chipping and very thoroughly cleaned with a heavy wire broom, so as to remove all dust and dirt. A jet of steam shall be employed to clean the wall, if available.

(b) To the mechanically cleaned surface apply with a large acid brush, a liberal coat of one to ten (1:10) solution of Hydrochloric Acid, (Muriatic Acid). Allow the acid to

In applying waterproofed plaster coat to either interior or exterior of brick wall the acid treatment is unnecessary. Surface should be thoroughly wet before applying plaster coat.



Waterproofing Concrete or Masonry by Means of Waterproofed Plaster Coat Applied to Exterior Surface

remain until it has exhausted itself, which will require at least ten minutes. Apply a second coat of acid solution if the first does not sufficiently clean and expose the surface of the aggregate.

(c) With a hose under good pressure, slush the surface so as to remove the salts and loose particles resulting from the action of the acid. Continue the slushing until the old concrete is thoroughly cleaned and soaked to its full hydrometric capacity. Thoroughly wire-brush the surface so as to remove the particles which have been loosened by the action of the acid.

(d) To the cleaned saturated surface apply with a strong fibre brush a coating of pure cement mixed to a thick, creamy consistency with water to which TRUS-CON Waterproofing Paste, *Concentrated*, has been added in the proportion of one (1) part of Paste to eighteen (18) parts of water. Rub in vigorously so as to fill all crevices and cavities produced by the action of the acid.

6. Application of Coating to Sides—Immediately after applying the above slush coat, the first coat of waterproofed cement mortar shall be applied to a thickness of three-eighths of an inch (3/8") directly on the slush coat, and well trowelled and rubbed into the crevices of the surface. This first coat shall be lightly scratched before showing initial set. Before this first coat has reached its final set, the second coat shall be applied, of equal thickness, so as to give a full average thickness of three-quarters of an inch (3/4"). Most special care shall be exercised to apply this finish coat before the first coat has reached its final set. The finish coat shall be thoroughly floated to an even surface and subsequently trowelled free from any porous imperfections.

7. Floor Coating—The floors shall be prepared and treated exactly as indicated above, and finished with a waterproof cement mortar to a thickness of two inches (2"). Special care should be exercised to bond the wall coating to the floor coating, so as to make the waterproofed coating continuous over the entire surface.

8. Pressure—Where water is running through the wall, proper drainage must be provided by drilling holes and inserting tubes in the wall, to concentrate the flow of water. With the pressure relieved, the waterproofed plaster coat shall be applied to the drained portions of the wall. The drainage pipes shall remain open until the waterproofed plaster coat has thoroughly set and is capable of resisting the pressure of its own adhesive strength, when the drainage pipes shall be closed with suitable plugs and overcoated with the waterproofed cement mortar.

9. Inspection—When hardened, the waterproofed plaster coat shall be sounded with a light hammer and all loose and defective plaster chall be cut out and replaced.

Specifications for Waterproofing Cement Stucco

1. Intent—It is the intent of these specifications to obtain a sound, permanent and waterproof stucco.

2. Materials—The materials composing the stucco shall consist of:

(a) Portland cement which has been carefully tested and found to satisfactorily meet the requirements of the Specifications of the American Society for Testing Materials.

(b) Sand which is practically free from organic matter and uniformly graded in size from coarse to fine.

(c) Hydrated lime that is uniform in quality and perfectly hydrated.

(d) TRUS-CON Waterproofing Paste, *Concentrated*, as manufactured by THE TRUS-CON LABORATORIES, Detroit, Michigan.

3. Proportions—The proportions of the above specified materials by volume, shall be five (5) parts of cement, twelve (12) parts of sand, and one (1) part of hydrated lime. One (1) part of TRUS-CON Waterproofing Paste, *Concentrated,* shall be added to every eighteen (18) parts of water used to temper the mortar.

4. Mixing—The cement and hydrated lime, after being thoroughly mixed dry to uniform color, shall be added to the dry sand and the whole manipulated until evenly mixed. The dry mixture shall then be tempered to the correct working consistency with water to which TRUS-CON Waterproofing Paste, *Concentrated,* has been added in proportion specified. The mortar must be thoroughly worked until perfectly homogeneous. This composition shall only be made up in lots that can be immediately applied, and any material that has been mixed with water over thirty (30) minutes before applying shall be rejected.

5. Application—All walls shown on elevation for stucco finish shall be two-coat work. The first coat shall be prepared as specified above, with the addition of long cow hair for keying when applied to metal lath. The face of the first coat shall be thoroughly scratched over to form a key for the finish coat, which shall be applied to a total thickness of one inch (1″), when the first coat has set sufficiently hard to safely hold it. The finish coat shall be carefully floated from any porous imperfections.

When plastering over a masonry surface, special care must be taken to thoroughly saturate the masonry with water and the plaster applied at once.

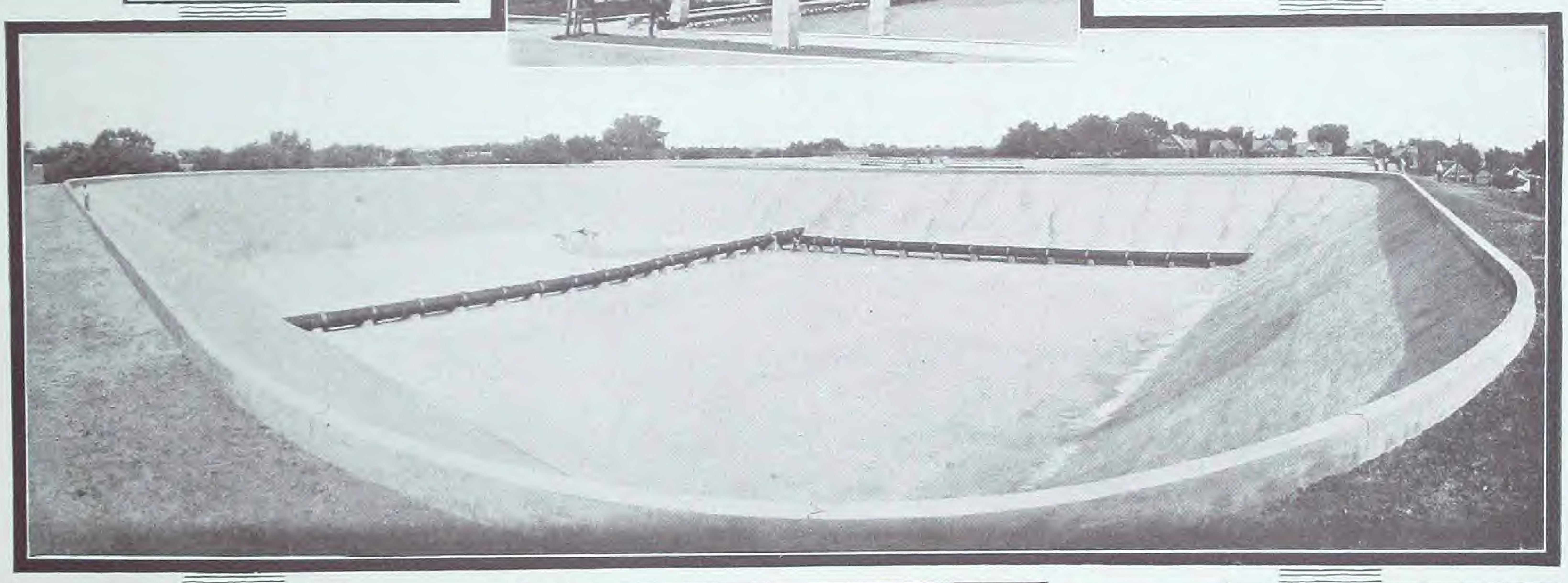
6. Drying—Special care shall be taken to avoid too rapid drying. If in direct rays of the sun, the stucco shall be protected with a damp canvas or burlap, and when sufficiently resistant, shall be frequently sprinkled with water.

7. No exterior plastering shall be permitted until all interior partitions are studded up and completely braced.

Trestle Miike, Coal Mine, Japan
Waterproofed to prevent electrolysis

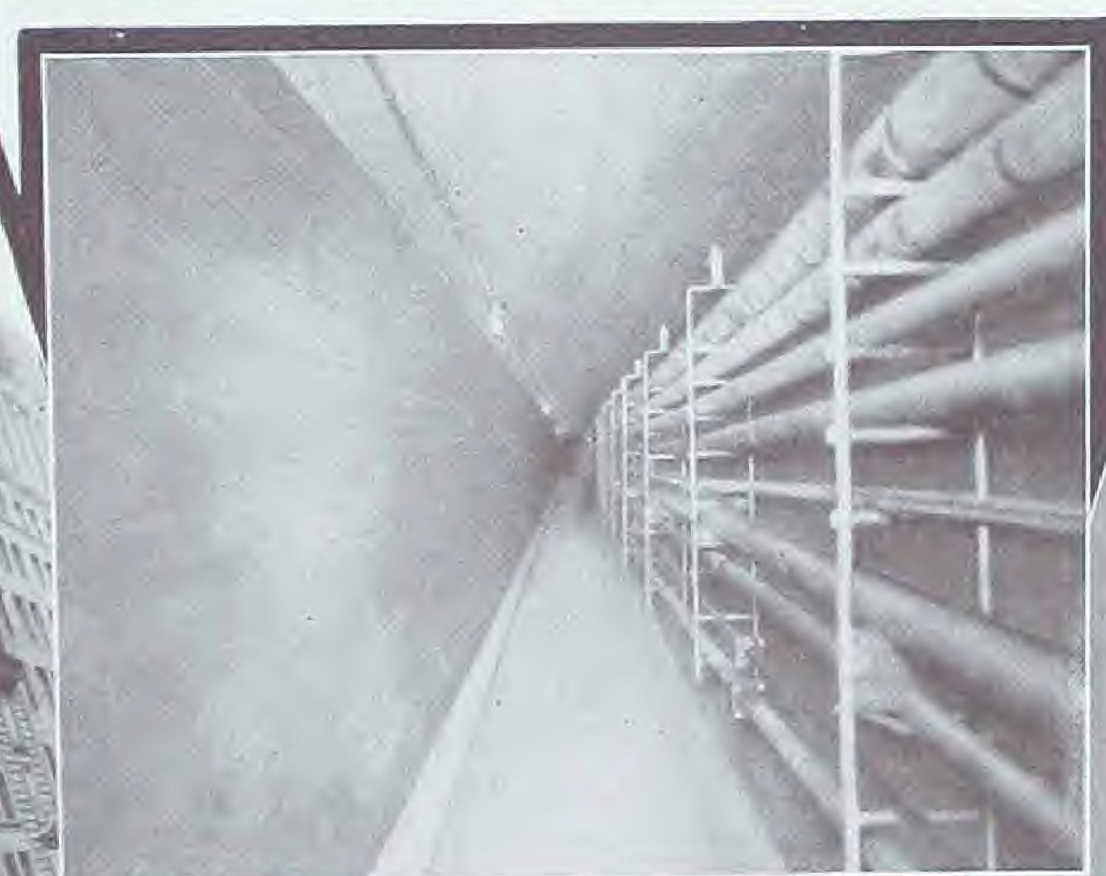
Carrick Public Swimming Pool,
Pittsburgh, Pa.,
Herman J. Lang, Architect

Residence of Mr. E. C. McGraw,
Miami, Fla., George L. Pfeiffer, Archt.
John B. Orr, Stucco Contr.



12,000,000 Gallon Reservoir,
Omaha, Nebr., George P. Prince, Chief Engr., Homer V. Knause, Const. Engr.

Van Tine Building
New York City, N. Y.



Tunnel at Kling's
Brewery,
Detroit, Mich.

Tunnel of Lehigh Coal &
Navigation Co.
Bangor, Me.

Users of
Trus-Con Waterproofing Paste, Concentrated

PART II.

Structural Waterproofing and Dampproofing

R. Alfred Plumb
General Director The Trus-Con Laboratories

The general subject of structural dampproofing and waterproofing as it confronts us today involves the methods and means of protecting structural materials against the disintegrating action of water. Masonry building materials are generally more or less porous and capillary in their structure, permitting the absorption and permeation of water. The presence of water in masonry is structurally injurious, due to its solvent action on any soluble content, but more particularly its disintegrating action by the expansive force that is manifested by the congealing of the water on freezing. Water that is drawn into foundations from the surrounding soil gradually ascends into the structure, due to the capillary nature of the constructive materials, and finally permeates the entire wall, producing damp and clammy conditions that foster and spread disease. While the subject of structural waterproofing and dampproofing deals primarily with the prevention of gradual decay and disintegration of structural materials, it also performs the useful and necessary function of providing more hygienic conditions for the benefit of humanity in general.

The subject of the protection of structural materials against the disintegrating action of water should, for the most comprehensive understanding, be considered under the two general divisions of Waterproofing and Dampproofing. The term Waterproofing should correctly be confined to the consideration of methods and means of protecting subterra construction and structures intended for retaining and containing water under and against hydrostatic head. Consistent with this definition, the term Waterproofing as a part of this great subject would apply directly to the methods of treating foundations, tunnels, reservoirs, cisterns, standpipes and similar construction. The term Dampproofing should correctly be confined to the consideration of the methods and means of keeping water and dampness out of the superstructure of buildings. In accordance with this definition, dampproofing should involve the various methods of treating exposed walls above grade line to avoid the entrance or penetration of moisture and dampness into the structure.

While there is a slight opportunity for discussion on the absolute literal correctness of the above definitions, nevertheless this division of the general subject serves most admirably to differentiate between waterproofing conditions and dampproofing requirements and to qualify the various materials into either waterproofing or dampproofing products.

It was only a few years ago that in the absence of any comprehensive understanding of this subject, transparent washes were recommended in the literature of manufacturers for treating foundations, tunnels and general subterra construction, with no apparent recognition that such materials have absolutely no application to these severe requirements. By making the above separation of this general subject, and with further sub-division of each individual part, the various materials can be very simply classified and confined for treating conditions where they have a useful and valuable application.

In a paper from one of our larger universities, which recently appeared in the technical press, the following statement was included in the introductory remarks: "Waterproofing materials for use with concrete are divided into four general classes—Membrane, Integral, Surface Washes, and Oil Paint Films." Such a statement can only be confusing, as it does not suggest or indicate any differentiation between the properties of the various materials which are suggested and is, in fact, no more progressive than the general understanding of the subject a few years ago when it was in a rather unfortunate and chaotic condition.

In the absence of a classification of this subject, it is very confusing to the engineer or architect to know exactly what material to select for any particular condition. Naturally, each particular product or method has some special properties that make it advantageous for certain conditions, and at the same time may have limitations that would correctly prohibit its use under certain requirements. Is it not advantageous to the development of this important subject to carefully consider the properties and behavior of each particular method, and so classify it as to be able to select

the material and the method that best suit a certain fixed condition?

The architect or engineer will find the following classification of this subject a big advantage in preparing his specifications and also in his general consulting work. As an example: If a client should inquire whether a simple transparent wash was applicable for treating the interior of a reservoir of considerable depth, he could very much simplify his reply with the advice that the method suggested by the client is fundamentally a dampproofing treatment and confined to conditions subjected only to dampness and has no application to a condition where hydrostatic pressure is to be withstood. The client can be easily made to recognize that his condition is literally a waterproofing requirement and that he must employ a method that has actual waterproofing value and not simply a material with such limitations as will only permit its use for dampproofing requirements.

Both the subject of dampproofing and of waterproofing can be sub-divided into various sub-headings, each of which has characteristic properties and insures quite a complete and comprehensive understanding of the full subject. The following discussion develops quite a full sub-classification of the two general subjects, with comment on the distinctive properties and values of each separate subclass.

The subject of dampproofing, which we have already defined as correctly applying to a consideration of methods and means of keeping water and dampness out of the superstructure of buildings, may be very simply sub-divided into the three following classes, viz:

A—Transport Coatings and Treatments.
B—Opaque Decorative Coatings.
C—Special Bituminous Coatings.

This classification is quite a complete one and includes practically every treatment that has ever been suggested or used to any practical extent in connection with the treatment of exterior exposed walls above grade line.

Again, the above classification of dampproofing treatments may be further sub-divided. The method involving the use of transparent coatings may be sub-divided into three quite characteristic sub-heads, viz:

(1)—The Sylvester Process.
(2)—Hot Paraffine and Waxes.
(3)—Special Proprietary Products.

(1) The Sylvester Process is one of the oldest dampproofing treatments, and while it has been used to some practical extent, it is at the present time very seldom considered. The Sylvester Process provides for the alternate treatment of a porous masonry surface with solutions of soap and alum. These solutions are preferably applied hot so as to insure good penetration and to accelerate the chemical reaction between the two materials. The theory of this treatment is to provide by inter-reaction of the soap and the alum, an aluminum salt of the fat contained in the soap, which will be deposited in the pores of the surface and tend to repel the moisture. While from a theoretical standpoint, the treatment may appear to be quite an effective one, yet on a practical consideration it is not very satisfactory. It is necessary to make a number of alternate applications of the soap and alum in order to obtain a sufficient quantity of the aluminum soap to provide any repellant or dampproofing action. The number of coats required is made necessary by the fact that the conditions of contact between the wash applications of soap and alum are not such as to insure a good, thorough chemical reaction between the two materials, and there is necessarily considerable soluble material left in the pores that is not utilized, due to the poor and inadequate physical contact.

(2) The second classification of transparent dampproofing treatments covers all of the various methods which have been proposed and used, involving the heating of the masonry surface and the application of melted paraffine or wax. While a dampproofing treatment of this type can be made very effective, its application is necessarily limited to only special cases where the high cost of its application is not prohibitory. The application can only be made slowly, as the surface has to be heated with a blow torch, and only when at the proper temperature can the melted paraffine or wax be applied, to insure the proper penetration and absorption of the repellent material into the pores of the surface.

A very representative incident of the use of this method for preserving masonry exposed to weather exposure is the application to Cleopatra's Needle in Grand Central Park, New York City, in 1885. This obelisk, while resisting the climatic exposure of old Egypt for ages, soon developed indications of rapid superficial decay when subjected to the climatic conditions

Classification of the General Subjects of Waterproofing and Dampproofing

- Protection of Structural Materials Against Disintegrating Action of Water
  - DAMPPROOFING
    - A-Transparent Coatings and Treatments
      - (1) Sylvester Process
      - (2) Hot Paraffins and Waxes
      - (3) Special Proprietary Products
    - B-Opaque Decorative Coatings
      - (1) Various Cement Washes
      - (2) Common Oil Coatings
      - (3) Special Proprietary Cement Coatings
    - C-Special Bituminous Coatings
  - WATERPROOFING
    - A-Integral
      - (1) Finely powdered dry compounds mixed with dry cement
        - (a) Repellent
        - (b) Non-repellent
        - (c) Metallic
      - (2) Compounds either in liquid or paste form added to water used to temper concrete
        - (a) Unstaurated Colloids
        - (b) Extended Colloids
        - (c) Concentrated Colloids
    - B-Membrane
      - (1) Coal Tar Pitch
      - (2) Natural Asphalts
      - (3) Special Bituminous Compositions

characteristic of our country. The stone was quite absorbent and as a result of the freezing of water in the pores, the outer surface of the stone was slowly disintegrating. In cleaning the obelisk previous to the application of the hot paraffine, about two and one-half barrels of pieces, weighing a total of nearly 780 pounds, were removed. Some of the pieces were so much decayed and disintegrated that they would crumble easily when removed from the surface. After removing the outer crust of disintegrated stone, the entire surface of about 270 square yards was heated and then immediately treated with a hot solution of paraffine.

(3) The third class of transparent treatments, viz: Special Proprietary Products, suggests quite an interesting and unfortunate chapter in the history of the development of the general subject of the preservation of structural work against the disintegrating action of water. Following the general recognition that one of the objections to concrete construction was its absorbent nature, there appeared on the market an almost innumerable number of transparent liquids presented with the most extraordinary and extravagant claims. According to the literature of the several manufacturers of these products, there was absolutely no condition associated with the general protection against water in constructional work that could not be very effectively and efficiently overcome by a simple application of their product. There was no intent or indication of a proper recognition of the limitations of a trans-

parent treatment, but they were recommended without qualification for tunnels, foundations, reservoirs, tanks, etc., in fact, every single condition that would require waterproofing treatment would find the manufacturers of these transparent treatments recommending their materials.

It will always be the subject of a great deal of regret on the part of all who are vitally interested in the scientific development of this important subject, that the manufacturers of these various transparent treatments did not exercise greater judgment in recognizing the limitations of their products. They were unfortunately prompted alone by the mercenary instinct of a quick return and profit on the sale of their material, not realizing that the ineffective and unsatisfactory results which would follow the use of their materials would tend to establish a general skepticism, and, in fact, disbelief in the efficiency and value of all waterproofing materials.

Practically all of the earlier proprietary transparent dampproofing products were nothing more or less than low metling point paraffines or waxes which had been melted and fluxed back into a volatile solvent. The theory of such a preparation is entirely correct, but unfortunately these several paraffines and waxes can only be dissolved in solvents to a very limited extent, producing a product that actually carries a very small amount of repellent base and an excessive amount of volatile material. On application to the surface, practically 90 to 95 per cent of the original material would be lost by evaporation, leaving only a small residue deposited in the pores of the surface. It would require a number of repeated applications in order to leave deposited in the pores of the surface a sufficient quantity of the repellent base to provide any efficient dampproofing results. Of course, it was usually recommended with these materials that two coats were all that was necessary in order to provide efficient dampproofing results.

There were a few materials that involved a little more technical effort than the simple solution of paraffine or waxes, but in the majority of cases only a small amount of actual total solids was introduced and not sufficient to impart any satisfactory dampproofing results to the surface over which they were applied.

The reason for not making more successful early progress on a transparent dampproofing treatment of this character is unquestionably the fact that the condition is by no means a simple one. A satisfactory transparent dampproofing material that is applied cold with a brush must be one that is practically colorless, as any tendency for the material to stain or discolor the surface is highly objectionable. Nature, unfortunately, has not provided many materials that offer possibilities for producing a product of this kind. The majority of products, when used in quantity sufficient to provide the necessary amount of total solids to give efficient dampproofing results, will impart such a color to the material that when used over stone that is more or less sensitive to discoloration, it will become badly stained, and the injury will be more serious than the difficulty which it was originally intended to overcome.

The repellent base held in solution in such transparent materials must also be of such a nature as will be more or less transparent after the volatile material has evaporated. This is an essential requirement, as the transparent treatments are used quite generally over porous brick or stone surfaces of various colors, and if the coating tends to leave a white deposit after evaporation of the volatile material, it will stand out in contrast to the colored masonry surface and appear as if the surface had a slight efflorescence.

The difficulties which the requirements for such a material presented, and the complaints which followed the use of so many of the inferior products, have resulted in the slow disappearance of a great number of products that originally appeared, and today there are only two or three of the materials on the market that were numbered originally among the great list of special products.

It is a problem that has involved a great deal of careful scientific investigation in order to select such materials which, due to their chemical affinity, can be so combined as to produce a synthetic base which has the properties of dissolving in the combination of solvents, to yield a product that will contain a comparatively high percentage of base so that when applied to a surface and the volatile material has evaporated, there will be a sufficient quantity of material deposited in the pores to fill them and change their natural absorbent nature to a negative repellent action.

B—The second class of general dampproofing treatments, viz: Opaque Decorative Coat-

ings, may be sub-divided similarly to transparent treatments, affording a very simple consideration of this important part of the general subject of dampproofing. This classification is as follows:

B—Opaque Decorative Coatings.
(1)—Various Cement Washes.
(2)—Common Oil Coatings.
(3)—Special Proprietary Cement Coatings.

(1) The first conception of applying an opaque decorative treatment is evidenced in the use of a mixture of cement and water applied with a brush, for the dual purpose of obscuring any imperfections in the surface and giving an outer shell that is of a denser texture, so as to protect the masonry from the penetration or absorption of moisture. While this treatment is more or less effective in uniforming the appearance of the surface, it hardly possesses any great or efficient dampproofing results. This is due to the fact that the cement is mixed with water and when applied the water occupies a definite volume and on evaporation leaves the surface full of small microscopic pores and apertures through which water can penetrate.

There is also considerable trouble experienced in using a cement wash, due to the difficulty in obtaining a satisfactory bond to the masonry surface, if the material is not applied to concrete that has not fully hardened. The usual result with a cement wash is that the coating will be efficient for a little time but after having been subjected to frost when thoroughly wet and saturated, it will be forced off from the surface by the expansion of the water on freezing, and any possible efficiency and value which it might originally have contributed entirely destroyed.

(2) The second class of opaque dampproofing treatments, viz.: ordinary oil paints, has been tried at various times with unsatisfactory results. This is very obviously due to the fact that in contrast to a wood or metal surface, a concrete surface is chemically active, due to the presence of alkali. When a common oil paint is applied over wood or metal, there is no chemical influence to in any way interfere with its normal process of drying to a tough, elastic linoxyn film. When such a product is applied over a concrete surface, the condition is distinctly different.

In the natural process of hydration of Portland cement, there is developed approximately 37 per cent of calcium hydroxide. It is the presence of this calcium hydroxide that contributes a distinctive alkaline nature to concrete surfaces. Any drying oil, such as linseed, is easily decomposed when in contact with an alkali, tending to form a soap of the metal represented in the alkali. In accordance with this natural characteristic of a drying oil, the calcium hydroxide reacts with the oil, forming a calcium soap which entirely destroys the characteristic toughness, elasticity and durability of the product. In place of a weather-resisting and preserving paint film, as would result if the material were applied over a wood or metal surface, only a sticky, incoherent, easily-perishing coating is left, presenting absolutely no dampproofing or uniforming effect.

Periodically we hear from various sources comment in regard to the use of lead and oil on concrete, which may be suggested by an occasional application that is more or less satisfactory. Actually, bitter experience has indicated that an oil paint is not adapted in its constituency to a concrete surface, and so long as a concrete surface is characterized by the presence of alkali—which, in fact, is an inseparable property—it will be impractical to attempt to use a product containing an oil that is so easily saponified.

Common oil paint is generally characterized by a glossy texture which is an objection for treating concrete surfaces. There is stability, strength and endurance associated with a masonry surface, and it is not consistent with good architectural treatment to apply an oil paint coating that will impart a glossy appearance so strongly contrasted to the naturally soft, flat texture of masonry surfaces.

(3) The third method of opaque dampproofing treatments, viz.: specialized cement coatings, offers the greatest opportunity for producing effective and satisfactory dampproofing results. With a full knowledge of the physical and chemical characteristics of a concrete or masonry surface, it is possible to select raw materials and so treat and combine them as to produce a product that is in every sense a specialized cement coating. Such a product cannot be produced by any effort to re-adapt a common oil paint, but must be built up fundamentally from special materials which, due to their physical characteristics and chemical properties, are suited for the production of a strictly specialized product.

C—The third class of dampproofing treatment involves the application of bituminous products to the interior of exposed walls. The treatments in the first two classes as outlined above are applied to the exterior of the superstructure, while the special bituminous products are distinct in being applied to the inside of the wall.

These products are black in appearance and usually of quite heavy body, being applied with a brush so as to provide a thoroughly continuous coating. They are characterized by indefinitely remaining tacky, and provide bond for a coat of plaster applied directly to the coated surface. It is to be emphasized that the prime purpose in the application of such products to interior walls is for dampproofing results, and the fact that they have the associated property of bonding a coat of plaster is distinctly secondary.

It has become a very general practice in construction work to provide for the application of such a dampproofing on the interior of all exposed walls, as it gives an element in the wall that will prevent the continuous penetration of dampness or moisture through the wall, which would injure and destroy the interior decorations and produce a damp and unhealthful condition.

The subject of waterproofing proper, as we have defined applying to the treatment of subterra construction and structures intended for retaining and containing water under hydrostatic head, may very correctly be divided into the two characteristic methods, viz.: Integral and Membrane, each of which has further subdivisions.

The Integral Method of waterproofing involves the addition of compounds to the concrete at the time it is placed, and becomes a unit or integral part of the mass. This method is also known as the Rigid Method of treatment in distinction to the Membrane, which permits greater movement and conformation in the structure without injuring the effectiveness of the waterproofing treatment.

The Integral Method has been received with a great deal of favor by engineers, and its application has been increasing quite rapidly. Undoubtedly the more general selection and specification of the Integral Method in preference to the Membrane, in general substructural concrete work, is due to the fact that the development in the design of reinforced concrete has served to enable the engineer to anticipate his tensile stresses and strain and provide against the rupture or cracking in the concrete by introduction of the proper area of steel. For all concrete construction work where proper reinforcing or provisions are made against cracking, the Integral Method is by far the most satisfactory, due to its greater general economy. Various compounds which are used for general integral waterproofing requirements may be divided into two classes characterized by the physical condition in which they are added to the concrete, viz.:

A—Integral
- (1) Finely powdered dry compounds which are mixed with the dry cement.
- (2) Compounds either in liquid or paste form which are added directly to the water used to temper the dry mixture of cement and aggregate.

The products coming under the first classification may be further divided, due to their characteristic physical properties, into three classes, viz.:

(1)—Finely Powdered Compounds Mixed with Dry Cement.
- (a) Repellent.
- (b) Non-repellent.
- (c) Metallic.

(a) The repellents were the first integral waterproofing compounds to be generally used. These materials are usually the metallic salts of various fatty acids that impart their characteristic repellent properties. The larger proportion of the repellent compounds are the lime salt of a fatty acid, combined with a greater or lesser content of hydrated lime. Such lime soaps were undoubtedly originally chosen as waterproofing compounds due to their characteristic water-repellent properties. The repellent feature of such a compound is an excellent property to possess when the material is uniformly and homogeneously distributed in the mass of the concrete, but its repellent nature makes even distribution quite difficult.

In the practical application of these dry repellent powders, the material is mixed in proportions varying from 1 to 5 per cent with the dry cement. The treated cement is then combined with the aggregate and tempered with water to proper consistency. It develops in practical operations that regardless of the care that may be exercised in the careful and thorough dry mixing of the repellent powders with the dry cement, there is the characteristic tendency to be expelled from the careful mixture when water has been added. This, of course, is particularly true when the concrete is mixed quite wet and there is greater opportunity for flow throughout the mass of con-

crete. In dry mixtures, such as are quite generally used in facing concrete blocks and artificial stone, the dry repellent powders can be used quite successfully, as the distribution can be maintained by holding the compound entrapped and imprisoned throughout the mass, with no opportunity to manifest its repellent properties, due to the dryness of the mixture. For general concrete operations, however, the repellent properties are greatly limited, due to their repellent action. The presence of quite a large percentage of hydrated lime is essential to serve as a ballast for the repellant material.

(b) The objection which has been taken by the engineering fraternity to the use of repellent products on account of the uncertainty in uniform results, has been a natural incentive to develop products which do not show this repellent action. These products are usually constituted on a basis of hydrated clay, aluminum hydroxide or some similar inorganic colloidal substance. In manufacture they are ground extremely fine so as to develop the largest possible surface area to intensify colloidal development. The partial efficiency of such materials is contributed by their void-filling value. They are also recommended as beneficial in lubricating the mass of concrete so that it flows together in a tighter and closer mass.

The limitation of such materials is due primarily to the fact that the products which are used, while of a characteristic colloidal nature, have not the capacity for sufficient colloidal development to fill out all the voids and apertures of a concrete mass and give a density that is absolutely impermeable. There is also considerable doubt in regard to the permanency of the colloids, due to the fact that when given opportunity of drying out there is some difficulty and delay experienced in their reverting back to their original colloidal volume.

(c) To complete the classification of various integral waterproofings which are mixed with the dry cement, metallic compounds should be mentioned. These products consist primarily of very finely ground metallic iron, and in their integral application are mixed dry with the cement in a similar procedure to other dry integral products.

The theory of the action or such products is the increase in volume that occurs from the oxidation of the iron. When the process is complete, in place of the fine particles of iron, there is developed the hydrated oxide, which occupies a volume much larger than is the case with the original iron particle. The great difficulty, however, in obtaining satisfactory results with the metallic powders when used in integral application is the fact that cement itself is strongly basic and the presence of the hydroxyl ions developed in the crystallization of the cement naturally inhibits corrosion and prevents the oxidation and development of the iron throughout the mass of concrete, which is essential for efficient results.

The second class of integral waterproofing compounds which are added directly to the water, either in liquid or paste form, has the great advantage of absolute certainty in even, uniform distribution throughout the concrete. These products are generally readily miscible with water, forming a colloidal suspension in the water, and as a result of thorough mixing of the water with the cementing materials, are correspondingly uniformly distributed throughout the entire mass. The compounds in this class may for the most complete consideration be divided into the three following classes:

(2)—Compounds in liquid or paste form added directly to water used to temper concrete.	(a) Unsaturated Colloids (b) Extended Colloids (c) Concentrated Colloids

(a) Under this class are included practically all compounds which contain unsaturated fatty acids that require reaction with the constituents of the cement in order to form the final waterproofing compound. These products are usually mixed with the water used to temper the concrete in proportions varying from 1:25 to 1:50.

The great general objection to the use of unsaturated colloids is the uncertainty of the effect upon the tensile and compressive strength of the concrete. The one constituent in the cement that is most reactive with the fatty acids in these unsaturated compounds is the calcium hydroxide, which also plays a very important part in the normal setting and hardening of the cement. The utilization of a portion of the calcium hydroxide for reaction with the unsaturated compound to form a waterproofing colloid will proportionately detract from the strength which the calcium hydroxide is intended to contribute in the normal hardening of the cement.

(b) Products included under the classification of extended colloids are not usually characterized by any tendency to enter into

reaction with the constituents of the cement, but contribute their efficiency by the characteristic colloidal nature of the compounds themselves. The limitation of the extended colloids is in the fact that in the process employed in the manufacture of the products, there is invariably associated with the extended colloidal compound more or less inert material which is not particularly beneficial in contributing waterproofing value. The presence of varying percentages of inert and inactive materials associated with the colloidal compounds naturally makes these compounds uneconomical, as they must necessarily be used in quite rich porportion in order to carry in sufficient of the colloidal substance to give satisfactory waterproofing results.

(c) The products included in this class are a further development of the extended colloids in that they contain only materials of a strictly colloidal nature, which are capable of contributing waterproofing value. In their manufacture the inert and inactive materials have been eliminated, so that the final product contains only colloidal substances and so combined as to develop the maximum colloidal value. The fact that such products are concentrated affords the maximum economy, as they can be used in leaner proportions and still provide the colloidal volume that is essential to fill out all the pores and apertures in the concrete and give the density necessary for impermeability.

B—The second general division of the literal subject of waterproofing differs distinctly from the integral method in that it does not attempt to treat the concrete, but rather to insulate it from contact with water by enveloping the structure in a continuous bituminous shield. The fact that the membrane is not a rigid or unit part of the structure permits a certain freedom of movement and action in the concrete without impairing the efficiency of the waterproofing treatment. This feature of the membrane system makes it suitable for waterproofing work not fully reinforced and liable to settlement or subject to vibration or shock, such as a railroad bridge.

It was early practice to simply coat the surface to be waterproofed with hot tar or asphalt, but it soon became evident that this was not sufficient, as the coating would crack with any movement in the wall. It was, therefore, necessary to employ some material in addition to the bitumen in order to contribute the necessary toughness and tensile strength. Burlap and coal tar felt have been extensively used for this purpose and some very satisfactory waterproofing operations have been carried out with such materials. During the last few years considerably more attention has been given to the nature of the waterproofing felt, and as a result there are now on the market especially manufactured felts which are both saturated and coated with bitumen and possess greater pliability and strength. By means of these felts more perfect membranes can be constructed, as the strength and toughness of the felt permit greater distortion and twisting to accommodate it to the design of the work.

The bitumens most generally used for cementing the felt together in constructing the membrane are coal tar pitch, commercial asphalt and special asphaltic compositions. While the general method in the application of the reinforcing felt and fabric with the bitumens is practically the same with all of the materials, there is considerable discussion in the engineering fraternity at the present time regarding the bitumens that are the most satisfactory. The discussions primarily concern the treatment of overhead railroad bridges to protect the public from dripping and also to protect the steel from corrosion. At the present time there is quite an apparent diversity of opinion among railroad engineers as regards the selection of the bitumen that is best suited for this treatment. The present consensus of opinion seems to favor the use of asphalts when exposed to the air, as they are more resistive to oxidation than is the case with coal tar products. The coal tar products are given preference in their application to subterra construction, where they are covered with earth filling and not exposed to free oxidation. In selecting any bitumen for waterproofing purposes, care should be taken to obtain a material at as low a melting point as the nature of the work will permit, as it not only insures greater elasticity when subject to cold temperature, but works much more freely and easily in applying.

The special asphalts which are used quite generally for membrane waterproofing are usually manufactured from a hard hydrocarbon, such as gilsonite, tempered with a petroleum residuum to impart the necessary elasticity. The residuums used in the preparation of these asphalts should be preferably strictly asphalt bases and contain the minimum percentage of paraffin which, being of a lubricating nature, impairs the necessary bonding properties of the asphalt.

Integral Waterproofing by the Cement Coating Process

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The term "INTEGRAL WATERPROOFING" is authoritatively intended to include any method whereby a chemical compound is introduced into a hydraulic cement product with the view of creating impermeability.

This general type of waterproofing is subdivided into two separate and distinct methods, each of which possesses characteristics that afford it individual merit and advantages. That method whereby a Waterproof Cement Facing or Coating is applied over the surface of the members is termed the CEMENT COATING PROCESS, while that method in which the waterproofing material is incorporated throughout the mass concrete of the structural members is characterized the WATERPROOFED CONCRETE METHOD.*

The manner by which the Waterproofing Compound is introduced into the mortar or concrete varies with the nature of the product. Waterproofing Powders are usually mixed with the cement either at the mill, or by hand just before use upon the job. Liquid compounds are generally diluted with water and poured upon the dry mixture of sand and cement or charged directly into the concrete mixer, while pastes are diffused throughout the tempering water. Manufacturers' directions for each individual material should be rigidly adhered to in all cases. It is of the greatest importance that the recommended quantity be incorporated, and it is manifestly of equal importance that the material be uniformly distributed throughout the mass.

For maximum efficiency the greatest amount of waterproofing material should be utilized without impairing the strength of the cement. Since, however, an excessive amount does tend to cause a decrease in the setting value, such excess should not be present in any portion of the final cement product.

The inference deduced by the layman who has but casually investigated the subject, that the more material used the greater the efficiency, is vitally in error in INTEGRAL WATERPROOFING. The writer has in mind an instance of a superintendent "wisely" instructing his foreman to use the Waterproofing "double strength" for a certain piece of work where the pressure was unusually great, and another where a Waterproofing Powder Compound was used in its undiluted state by throwing it against the surface in attempts to remedy a leaky pit. Such cases appear absurd to anyone familiar with the subject, but Waterproofing Compounds are maltreated and misused perhaps to a greater extent than any other building commodity, this being due largely to the lack of appreciation that Masonry Waterproofing presents a truly scientific proposition.

INTEGRAL WATERPROOFING when intelligently executed is perhaps the most efficacious of all the systems in vogue, and the fact that it has been condemned in innumerable instances is due entirely to incorrect usage, improper application and the lack of comprehension of its exact function.

Of the two methods under discussion, the CEMENT COATING PROCESS especially requires the utmost diligence to secure the desired result. In fact, this work should preferably be undertaken by a specialist in this particular line, as the necessary observances and the precautionary measures are of such importance that the average contractor is not fully qualified for the successful performance of the work.

Before applying the Waterproofed Coating the surfaces must be especially prepared that a suitable bond be obtained. In fact, this preparation of surface is most important and many of the past failures in the application of the Process may be attributed to the lack of care in this operation.

The proper bonding face is obtained by thoroughly roughening, cleaning and grouting the surface. The Wall or Floor Slab must be saturated with clean water to destroy excessive capillarity, for otherwise the pores of the masonry will absorb a large percentage of the gauging water together with the finer particles of cement, and the strength and efficiency of

*The writer assumes responsibility for coining these expressions descriptive of the two general methods, and as hitherto a great deal of confusion has existed in the construction of the term "Integral Waterproofing," as to which of the methods is referred to, he trusts that these expressions will come into standard usage.

the Coating be impaired. Particularly in the case of brick walls or floors should the members be thoroughly wet down owing to the great absorptive property of this material. A slight amount of absorption is desired, however, as it assists materially in obtaining the necessary bond.

In the case of concrete walls the entire face is chipped to expose the aggregate, while for brick and rubble the joints are raked and the surfaces roughened. For floors it is highly advantageous to apply the Waterproof Coating the day following the placement of the concrete slab in order to simplify the bonding operation. When the Coating is applied over old concrete floors similar precautions as for walls must be observed.

THE CEMENT COATING is prepared by an intimate mixture of Portland Cement and coarse sand with the incorporation of an Integral Waterproofing Compound. Proportions of one part cement to two parts sand are best adaptable for the purpose, as mixtures considerably leaner than this are too porous, whereas Coatings of richer mixture have a tendency to crack under temperature changes.

For Waterproofing vertical surfaces the Coating is applied in two coats, scratch and finish, giving a total thickness of $\frac{3}{4}''$ to $1''$,

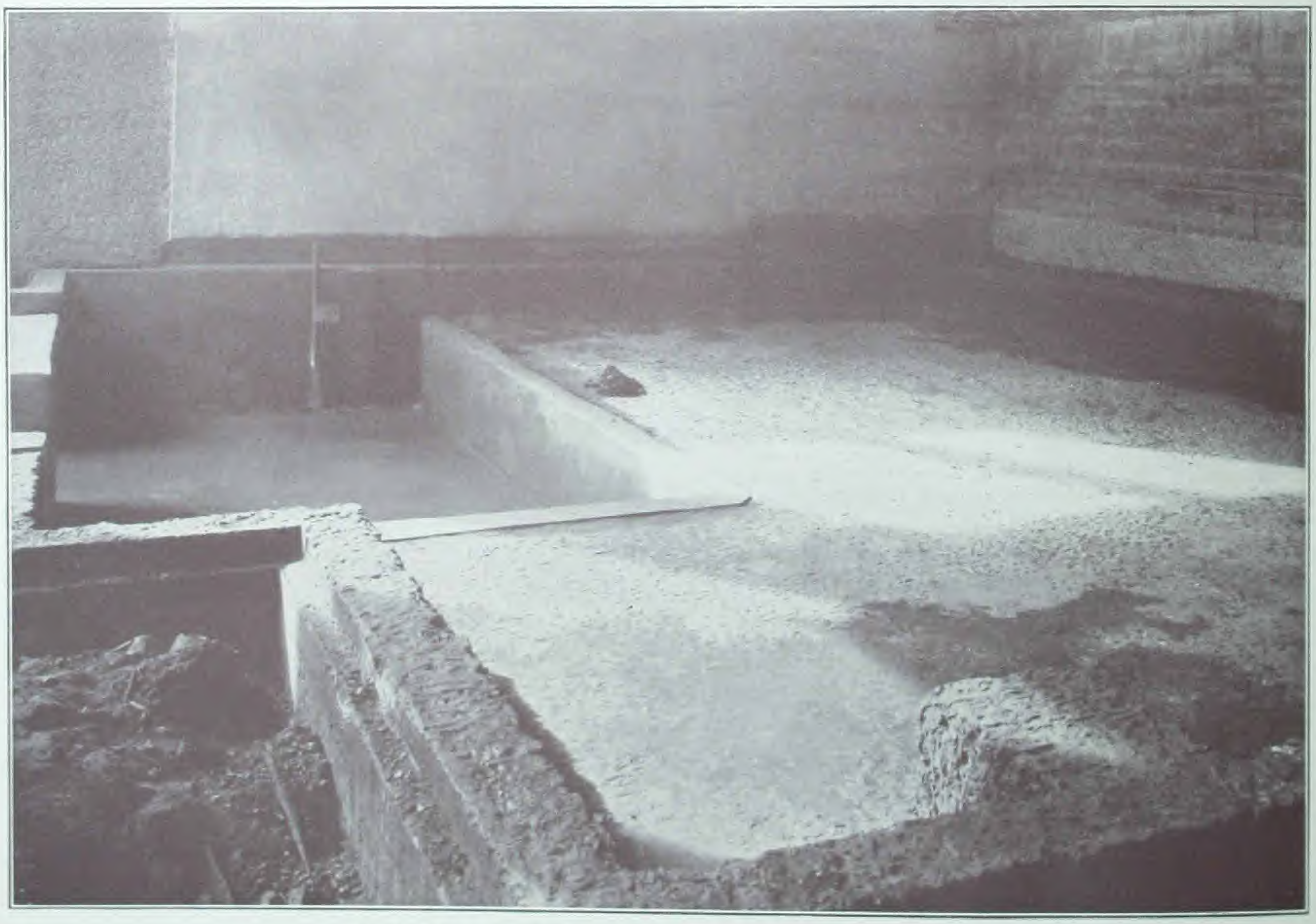

PLATE No. 1—Typical View Showing Waterproofing Work in Progress.

Site of future boilers, Ward Bakery, East Orange, N. J. Pit at the left for fire-boxes of boilers. Floor grade at elevation of top of wall in foreground, allowing entire area under boiler depressed to allow for insulating coat. Complete substructure of this building waterproofed by the CementCoating Process. C. B. Comstock, architect, New York City. Cump & Co., General Contractors.

while for horizontal surfaces the Coating is placed in one operation 1″ to 2″ in thickness. The second coat for vertical surfaces should follow the first at an interval not exceeding 18 hours under normal conditions, as after final set has taken place the pores of the Waterproofed Scratch Coat, being negative in capillarity, tend to repel the grouting particles of the finish coat, resulting in a lack of adhesion.

Sometimes the architect requires the Cement Coating to be applied over the exterior face of the walls and below the pressure resisting slab of the floor, in disposition similar to that of the Waterproofing in the Membrane Method. This scheme should be discouraged, however, as the chief advantages of the Process are lost thereby.

proofing. In some cases where the construction permits, the grillages are encased in Waterproofed Concrete under the direction of the Waterproofing Contractor, and the Waterproofing of the floor carefully joined thereto.

Plate No. 1 shows a typical view of work under way. In the background a portion of the wall has been coated, while to the extreme left the surface has been chipped preparatory to receiving the Coating. The Waterproofing of the pit has been completed, and the floor and foundations in the foreground prepared and cleaned for the installation of same.

In Plate No. 2 the general scheme is illustrated for carrying the Coating continuously over various portions of the building. Par-

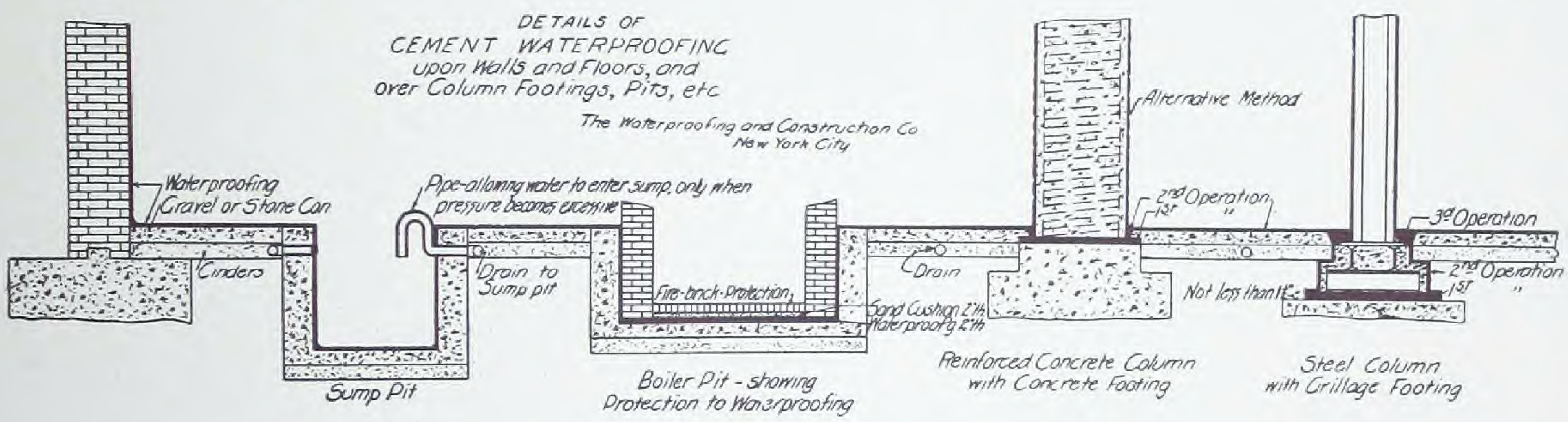

PLATE No. 2

The correct position for the Waterproof Coating is upon the inside faces of the members; that is, the Coating should be carried over the interior surfaces of the exterior walls and the upper surface of the lower level Floor Slab, and unless some special interior finish is desired the Coating should ordinarily be left exposed. It is trowelled smooth to an even surface, and presents a Wall Plaster Finish and Cement Floor Finish of highest grade. When fully cured, the Coating is of light gray, uniform in color and pleasing in appearance, but if preferred it may be painted to the shade desired by employing strictly specialized Concrete Coatings.

The Waterproofing is carried continuously over all pits, trenches, etc., and either up the sides of the interior columns to the required heights or over the footings and up around the column bases to join with the Floor Water-

ticular attention is called to the necessity of insulating the Waterproofing, where abnormal conditions prevail. Upon boilers and wherever the surface will be exposed to intense heat, the Coating is depressed some six or eight (6 or 8) inches to allow the placement of a protective coat of sand and firebrick, a slab of cinder concrete or other suitable heat resisting medium. Plate No. 3 portrays the Waterproofed Coating depressed for this purpose just preparatory to the installation of the protective coat.

The Coating should be carried under all machine foundations, that it be not subjected to excessive vibration and that its continuity be not destroyed by the anchor bolts. Where cold water pipes enter the building, the Coating can in general be bonded to them directly by carefully removing all paint and roughening the metal. However, where hot water or steam

pipes are encountered, metallic collars allowing for the lateral movement of the pipes should be supplied, the Coating bonded to the collar and a plastic material forced into the void between the collar and the pipe.

The matter of construction joints in the Coating between different day's work is all-important, as these will develop points of weakness unless they be specially treated. A fresh straight edge an inch within the edge of the completed work should be cut and this thoroughly grouted to aid in the knitting process. The joining should never be placed at the juncture between the wall and floor or at angles in walls as it is quite impossible to adequately trowel the work at these points.

Since the Waterproofed Coating is applied over the opposite face from that against which the pressure is exerted, the bond with the underlying base must be absolute. When this is attained the efficiency of the Waterproof Coating is limited in its resistance to hydrostatic pressure only by the strength of the structural member.

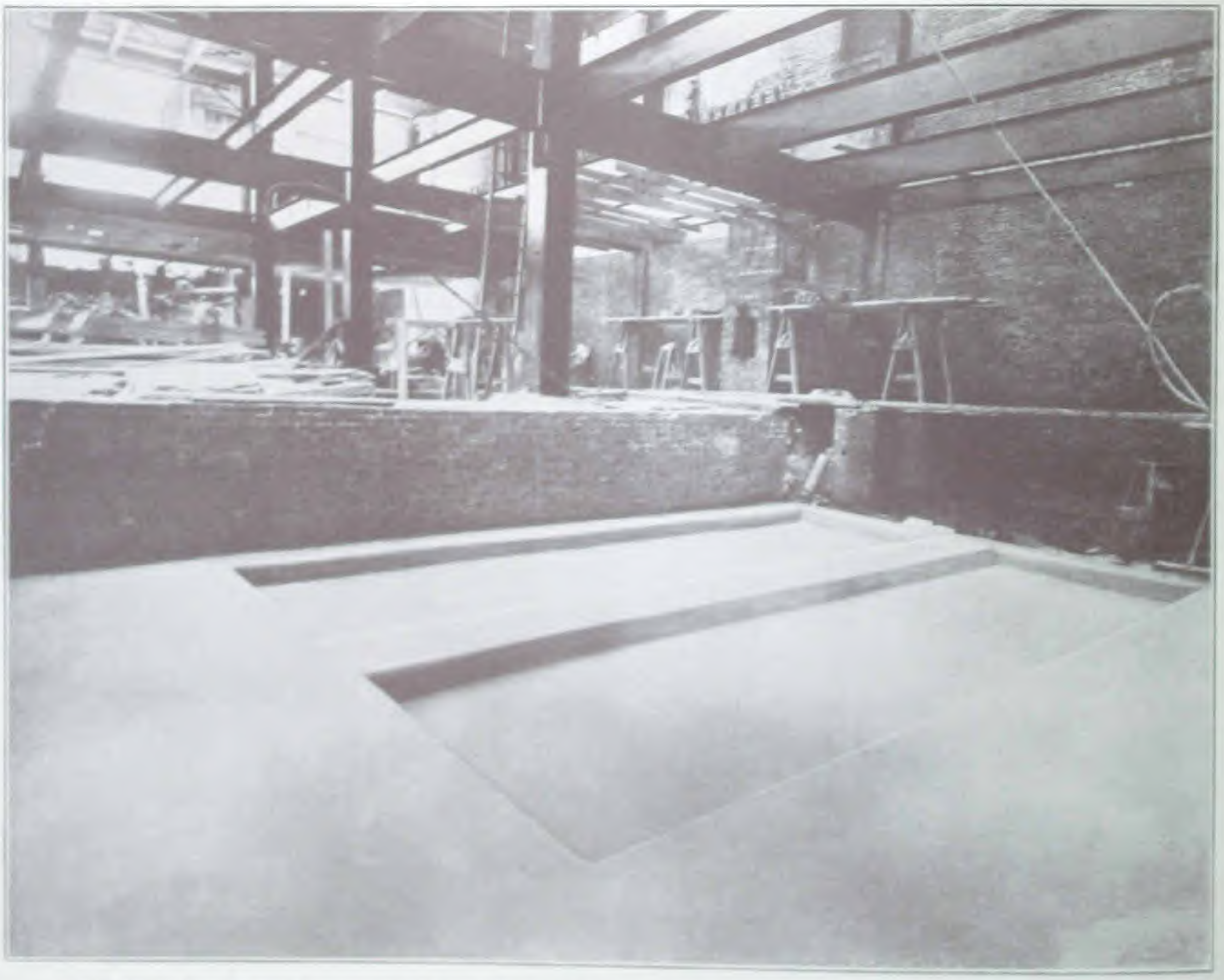

PLATE No. 3.—View Showing Depression in Floor for Protective Coat Under Boilers. Alan Realty Building, 37th Street and Broadway, New York City. Geo. and Edw. Blum, Architects. Alan Realty Const. Co., Owners and Builders.

When the bond is positive, the Waterproof Coating forms a series of beams or arches over the minute pores of the masonry and effectively seals the water in their separate channels. The span of the beams is of course of infinitesimal length only, and thus the total force applied upon each individual beam and the consequent stresses exerted are of negligible magnitude; also it is quite probable that the pressure is lost to a large extent by the capillarity, depending for this feature upon the impermeability of the masonry itself. Only so long as the particles of water are confined within their tiny channels does the Cement Coating possess real efficiency, for if the water be allowed to collect in a continuous sheet behind the Waterproofing (which may occur when the bond is imperfect) the beams become of appreciable length and the coating is ruptured or forced from its position.

Considering these facts, it is readily perceived that the success of the Process is dependent to a very great extent upon the efficiency of the bond existing between the Waterproofing and the underlying base. Only by virtue of this bond is it possible to attain such excellent results by applying the Waterproofing upon the interior faces of the members.

The fact must be always borne in mind that the actual function of any Waterproofing agent is to make the masonry impervious and that it is not a pressure resisting medium of appreciable structural strength. Thus if a wall or floor slab, efficiently Waterproofed, be subjected to stresses beyond its ultimate strength, the member itself will fail and the Waterproofing be ruptured. Obviously this failure cannot be attributed to any fault of the Waterproofing and in the design of a structure due allowance must be made for adequate strength of the members to resist hydrostatic pressure when such exists or is likely to exist. This truth is apparent, but in the mass of detail that enters into the design of a structure its importance is often not appreciated.

The control of water during the progress of construction work is important as the Coating, of course, is of such nature that it is unable to resist hydrostatic pressure until it has become fully hardened. Various means are devised for relieving this pressure, and no little ingenuity is required to successfully apply the Waterproofing against members through which water is percolating.

The general method of procedure in such cases for vertical surfaces, is to drill holes through the wall at various points to concentrate the flow of water. Metallic or porcelain tubes are inserted, protruding several inches from the interior surface of the wall to prevent the water from flowing over the fresh Coating. Where the floor is being simultaneously Waterproofed, rubber tubes are attached to the metallic or porcelain ones to conduct the water directly to a sump pit.

When hydrostatic pressure exists, before placing the slab of horizontal members, the best method is to construct a drainage system so that this pressure can be temporarily relieved. Excavation should be made some eight or ten (8 or 10) inches below the lower side of the proposed slab and this backfilled with cinders, gravel or similar porous material. Drains of hollow tile should be constructed at intervals, converging to sump pits. Pumping or bailing should be resorted to from these pits until the concrete has attained its initial set, and then again for some ten to fifteen (10 to 15) hours after the Waterproof Coating has been placed, or until the latter has become sufficiently set that the water will overflow the sump pit, and not seep through the Coating, as in this latter event its efficiency will be entirely destroyed. After final set of the Coating has obtained, the sump pit can be sealed.

As may be ascertained from the preceding discussion, where water exists during construction work, the walls may be erected regardless of the Waterproofing, but the floor slabs should not be placed until proper means have been taken to control the water.

Where this scheme is not followed or in the case of the repair of leaky floors, it is necessary to install drains in trenches. These should be cut entirely through the members, or at least to such depths that the flow will be concentrated, and that concrete of sufficient thickness to resist the pressure can be placed above the drains. Both of these requisites must be fulfilled. Great care must also be taken that the new concrete in the trenches be carefully bonded with the old, so as to form a continuous slab possessing adequate structural strength.

When scientifically undertaken the Cement Coating Process is absolutely positive and permanent in its results and its merits as a Waterproofing medium are excelled by no other method.

Analytical Reasons for the Necessity of Incorporating a Waterproofing Compound in Concrete

By R. Alfred Plumb

In determining the strength and resistance of structural materials, one of the most important properties to consider is density. With density are associated solidity, strength and endurance. Contrasted with density, considered as the proportion of mass or quantity of matter to volume, porosity would represent the actual unoccupied space in the total volume. With porosity are associated weakness, deficiency and decay.

The metallic structural materials, such as iron and steel, have the highest densities. In the processes employed in the manufacture of steel, the conditions are all favorable for producing a product of high density. Also, in the subsequent rolling and shaping of the metal the treatment is one tending in the direction of greater density and greater compactness. In the process of cooling after the metal has been poured in the forms, also in the treatment which the metal receives in the process of rolling and shaping, there is no substantial evaporation or volatilization of any constituent or inherent part of the metal. In the absence of elimination of any constituent part after the metal has taken definite shape or definite volume, there is no opportunity for developing unoccupied space or volume so as to impart porous characteristics to the metal. The constituents and elements of the metal are fixative and there is no characteristic elimination of any substance by any processes that would develop porosity.

It is also characteristic of various rocks that are employed extensively in construction work to possess a high ratio in the proportion of actual mass or quantity of matter to bulk or volume. This high density is due to the fact that in the mineralogical formation of the rock the processes were such as tended to fill out with mass all available volume and not leave any unoccupied space in the final formation.

In structural materials as well as the majority of other substances which are characterized by low density, the porosity is generally formed by the elimination, either by volatilization or evaporation, of some original constituent of the particular substance.

Charcoal is a characteristic porous substance. Charcoal, as is general knowledge, is prepared by the dry distillation of wood. Wood in the original form consists of cellulose, resins, lignine, and various inorganic salts and water. After dry distillation at a temperature of 400 to 450 degrees Centigrade, which is the characteristic temperature in the preparation of charcoal, all of the volatile matter is driven off and the residual charcoal consists of practically the fixed carbon and the inorganic constituents of the wood, representing only about three-fourths of the volume and usually about twenty per cent of the weight of the original wood.

Similarly, our common coke is manufactured by the destructive distillation of coal. The actual porosity of the coke will naturally depend upon the nature of the coal from which the coke is produced. With anthracite coal the volatile hydrocarbons are low, while with bituminous coals the volatile hydrocarbons are high, and the actual porosity or unoccupied volume in the coke will be in direct proportion to the percentage of volatile hydrocarbons which is eliminated in the distillation of the coal.

Quick lime serves as an excellent example of a substance of low density, due to the high porosity resulting from the elimination of the carbon dioxide from the limestone burned to produce the quick lime. As a result of the loss of water, organic matter and carbon dioxide during the burning of limestone, there is a great reduction in the weight of the original material, but only a slight decrease in its volume. As a general case, 100 pounds of good limestone yield about 58 pounds of lime, but the shrinkage in bulk is not over 10 to 15 per cent of the original volume of the limestone. The small reduction in volume during burning, compared with the big loss in actual weight, indicates the development of a very porous structure in the quick lime in direct proportion to

the volume left unoccupied by the elimination of the constituents driven off in heating.

The porosity of our common burnt brick is largely in proportion to the water, inorganic matter and gases which result from the decomposition of the carbonates and similar minerals present in the clay. While the brick after being pressed is quite compact and dense, after being burned the structure is quite porous, due to elimination of the above substances.

It is to be emphasized in citing the above examples that in a large number of cases the actual porosity of a substance is in direct proportion to the original constituents which are elimiated by natural evaporation or in gaseous form under the action of heat. With steel there is no constituent for substantial evaporation after the material has reached the molten state, and every treatment is one to produce compactness and density, while with charcoal, coke, lime, brick, etc., the treatment in manufacture involves the evaporation and elimination of a large percentage of the original constituency, leaving an unoccupied volume or porosity in proportion to the eliminated elements.

Porosity, therefore, in connection with various substances can be quite accurately defined to be in direct proportion to the volume left unoccupied by the evaporation or elimination of an original incompressible constituent.

According to this reasoning, the porosity of concrete would be substantially in proportion to the volume in the mass left unoccupied by the evaporation of the larger portion of the water which is an important constituent of the original concrete. The function of the water used for tempering and mixing Portland cement concrete is both physical and chemical. A comparatively large excess of the water is required for the physical function of providing a somewhat liquid consistency that will permit the placing of the concrete in forms and its spading and tamping to produce the greatest compactness. Water is also necessary to enter into chemical reaction with the cement to provide for the natural solution and hydration of the cement essential to form the necessary crystallization to bind and cement together particles of inert aggregate. In the chemical changes a portion of the water actually becomes a constituent part of the final composition of the hydrated cement, but the larger percentage is unnecessary for hydration and is eliminated by natural evaporation, depending upon the mass of the concrete and the existing temperature.

In general concreting practice between 25 and 30 gallons of water are employed for tempering a cubic yard of 1:2:4 concrete to a medium wet consistency. Taking 27.5 gallons per cubic yard as an average, and the weight of water at 8.34 pounds per gallon, there would obviously be introduced into each cubic yard of concrete approximately 229.35 pounds. As water under normal conditions of temperature and pressure weighs 62.5 pounds per cubic yard, the 229.35 pounds would be equivalent to 3.67 cubic feet of water. According to this calculation, approximately 3.67 cubic feet of water are used for tempering concrete comprising one cubic yard.

Estimating liberally that 25 per cent of this water would be utilized in entering into actual chemical reaction with the cement in the processes of hydration, there still would remain 2.75 cubic feet of free water. Also making a further liberal allowance that 25 per cent of the 3.67 cubic feet of water is retained in the colloidal development of the cement, there still remains an absolute minimum of 1.84 cubic feet of water to be elimiated by evaporation. This is a little less than seven per cent of the total volume, which would be left unoccupied by the evaporation of the water. This factor agrees quite favorably with observations that have been made to determine the actual absorption of a throughly dry concrete.

It is the function of an integral waterproofing compound to occupy the volume left free and unoccupied by the evaporation of the water. The integral waterproofing compound should correctly exhibit some repellent action after it has been uniformly distributed throughout the concrete. The development of this repellent property is an advantage in preventing the absorption of water into the capillary structure of the mass.

More important is the necessity of the integral waterproofing compound possessing colloidal properties or capacity of retaining a larger percentage of the water to provide for full colloidal development of the integral waterproofing compound, in order that through its voluminous development all the pores that would otherwise be left free and open may be occupied and full density provided.

The Physical Characteristics of Integral Waterproofing Compounds

By R. Alfred Plumb

With the rapid increase in the popularity of the integral method of waterproofing, there has occurred an interesting evolution in the nature and characteristics of the integral waterproofing compounds.

In the integral method the waterproofing compound is introduced directly into the mass of the concrete, and the thoroughness with which it is distributed throughout the mass depends very largely upon the physical characteristics of the compound.

The method by which the integral waterproofing compound is introduced into the concrete mass serves as a very simple, general means of classification of the various integral products. This classification would include the two general heads of finely powdered dry compounds which are mixed directly with the dry cement, and a second class of compounds which, in either liquid or paste form, are added directly to the water used to temper the concrete.

Figure 1

The compounds furnished in finely ground powder, which must be mixed evenly and uniformly with the dry cement, represent the earlier conception of the requirements of an integral waterproofing compound. In the practical use of these compounds, from two to

Figure 2

five pounds of the material are recommended to be mixed dry with each bag of cement. To insure effective mechanical distribution, it is necessary that the required amount of material is thoroughly dry-mixed with the cement. This operation generally involves considerable labor and has proved one of the serious handicaps which has retarded the more extended use of the dry compounds.

The compounds included under the general class of dry powders which in application must be mechanically mixed with the dry cement can, for the most comprehensive consideration of their physical properties, be divided into repellents, non-repellents and metallics. All of the various dry powder compounds, con-

sidered from the standpoint of their physical characteristics, are included under one of the above-mentioned classes.

The compounds which are characterized by a repellent action of the water were among the first of the dry powders that were generally used. The repellent properties of these compounds are contributed entirely by the presence of metallic soaps which have the inherent characteristic of being immiscible with water. It was only quite natural that these dry repellent soaps would be among the earlier conceptions of the integral waterproofing, as the interesting

Figure 3

property of being immiscible with water would readily suggest that they possessed advantages in repelling water from entrance into the concrete, if they could be introduced in a uniform distribution throughout the concrete mass.

While theoretically this conception seems excellent, yet in practical operations it has been repeatedly demonstrated that the repellent nature of the compounds is exactly the characteristic that prohibits even and uniform results. Regardless of the care that may be exercised to insure the most even and uniform mechanical mixing of the repellent compound with the dry cement, when the cement is tempered with water the compound has the marked tendency to separate out, due to its immiscibility with the water.

Figure No. 1 shows an interesting experiment to demonstrate the marked repellent nature of these compounds containing metallic soaps. To a beaker about two-thirds full of distilled water was added a weighed amount of a representative repellent compound. The mixture was subjected to very vigorous mechanical agitation for several hours, and at the conclusion practically all of the repellent compound was still retained on the top of the water, showing no tendency for mechanical mixing with the water. It is exactly this repellent feature which in earlier conception seemed a valuable characteristic, that has proven a serious objection to the use of such compounds.

An interesting analogy emphasizing the physical behavior of the repellent compounds would be the result of an effort to keep finely ground cork distributed throughout the mass of the powder with which it was originally mixed dry, when water was added to the powder so as to produce a thin paste. Very naturally the cork, due to its lighter gravity and its repellent action, would separate itself from any uniform mechanical distribution that might have originally been provided, and tend to collect on top of the water.

Quite naturally the extent to which the dry compound or repellent product will be ejected or expelled from its mixture with the cement will depend upon the consistency to which the concrete mass has been tempered with water. With very dry mixtures the compound will be held mechanically entrapped, but in mixtures that are sufficiently wet to be consistent with

Figure 4

those generally used in practical concreting, there is enough opportunity for movement in the mass so that the even distribution of the repellent compound will be destroyed by its natural tendency to stratify and segregate throughout the mass.

The second class of dry compounds that are added directly to the cement is a very natural evolution developing from the observed behavior of and the objections to the repellent compounds. With these non-repellents there is naturally no difficulty experienced in maintaining uniform distribution in the cement, as they are as thoroughly miscible with water as the cement itself.

One of the interesting features that is claimed for these dry compounds is that due to their colloidal nature they serve as lubricants and provide greater density due to the greater compactness of the concrete. This lubricating characteristic, intended to bring the particles of aggregate and mortar in closer contact, is doubtless one of some consideration, but this simple property of an integral product is not the prime function in determining the effectiveness with which the concrete is rendered waterproof. An integral waterproofing to be effective must serve to accomplish a great deal more than simply providing a little freer consistency in the concrete that will insure its flowing together to a little tighter and closer mass.

The important limitation of the non-repellents is due primarily to the fact that the compounds are not of such a nature, nor do they lend themselves to any treatments that will insure the development of their colloidal properties, which according to the latest conception of integral waterproofing are essential for thoroughly effective results. While the compounds may originally have some colloidal properties, the non-repellents are characterized by colloids which are termed technically non-reversible. On the drying out of the concrete there is a tendency for the non-repellents to lose their collidal properties in giving up their moisture. In this condition, even though the concrete may again become wet, the non-repellents are extremely slow in reverting to their original state and in some cases it is questionable if they have any property of returning to their original colloidal condition, in order to develop to the necessary volume to fill out and occupy all the internal voids and interstices, essential to give a density that will be impermeable.

For completeness in the classification of dry powder compounds that are added directly to the dry cement, mention should be made of the metallic products. These compounds have contributed very little to successful integral waterproofing treatments, due primarily to the fact that they are composed largely of finely ground metallic iron. When mixed with cement and surrounded by an alkaline medium, there is no opportunity for corrosion or development of the physical volume of the iron, and they remain only as inert, inactive, mechanical fillers of practically no more advantage in the mass than fine aggregate.

The second general class of integral compounds, namely the products which, either in liquid or paste form, are added directly to the water used to temper the concrete, marks the most important and valuable improvement in the subject of integral waterproofing. The objection of the contractor to the added labor cost and effort involved in the dry mixing of the powder compounds with the cement, and the intelligent criticism of the architect and engineer in recognizing the impracticability of keeping such compounds properly mixed with the mass, were fully met and solved by the introduction of products which are added through the medium of the water.

Figure No. 2 illustrates an easily conducted experiment which very clearly emphasizes the practical advantages of the compounds which are added directly to the water. In this experiment one part of a compound in paste consistency was added to twenty-four parts of water, and after very little agitation produced an even, uniform mixture of milky appearance. In this particular experiment the compound remained for several hours in suspension, demonstrating that on addition to the water the paste compound formed an almost perfect colloidal suspension in the water.

It is obvious that a paste compound of this nature which, with very little agitation, becomes so thoroughly and uniformly mixed with the water, with which it indefinitely remains in suspension, will through the medium of the water be carried throughout the entire mass of the concrete and give a thoroughly uniform waterproofing result.

In practical work the operation of the introduction of the paste compounds which are miscible with water can be very simply conducted. Figure No. 3 illustrates a concreting plant

where a temporary platform has been constructed above the mixer. This platform should be built strong enough so as to support the weights of a barrel of the waterproofing compound, two barrels of water, together with the weight of usually one workman, who will provide for the mixing of the paste with the water in the proportions in which it is recommended to be used.

Figure No. 4 illustrates the simple method of providing for two empty barrels, each connected by pipe so as to deliver its contents directly into the mixer. While the mixture of paste and water in one barrel is being used for tempering the concrete in the mixer below, a new mixture of paste and water can be prepared in the second barrel, and by this alternating process one barrel will always be in readiness for use and there will be no opportunity for retarding or in any way delaying the concreting operation.

While the illustration shows two workmen on the platform mixing the paste compound with the water, it is generally accomplished by one man, as the paste compound, to be a thoroughly effective and practical one must mix with the water easily, so that the whole operation involves only placing a measured quantity of the waterproofing in the barrel and then filling the latter with water from a pipe connection that is provided on the platform.

This method of introduction of the waterproofing compound naturally appeals to the contractor, as it is one that requires very little additional labor cost, since the manipulation is so easy and simple. It in no way interferes with the rate or speed of mixing the concrete, as the workman on the platform will always have the mixture of paste and water in proper proportion ready, and by being elevated above the mixer is not in the way so as to interfere with or complicate the conveying or depositing of the concreting materials in the mixer.

Grand Central Terminal, New York City—Service Room Floors Waterproofed with Trus-Con Waterproofing Paste, *Concentrated*

Integral Waterproofing with Particular Reference to the Waterproofed Concrete Method

By A. D. Hyman*

That method of Masonry Waterproofing whereby a chemical compound is diffused throughout a hydraulic cement product is popularly known as the Integral Method. Variations of this general method appearing under trade names or terms descriptive of the operations involved or the products employed are in vogue, but all may be classified under the headings, THE CEMENT COATING PROCESS and THE WATERPROOFED CONCRETE METHOD.

In the former a facing or coating of Waterproofed Cement Mortar is applied over the surface of the member in such a manner as to be securely bonded to it. For substructural waterproofing, this is generally placed upon the inner faces of the walls and over the upper surface of the floor-slab, its disposition being such that it can be installed with minimum expense, and also that it may act as the floor wearing surface and wall plaster finish. It is proposed herein to deal particularly with the WATERPROOFED CONCRETE METHOD in which the Integral Compound is diffused throughout and becomes an integral part of the mass concrete.

In order to have a full comprehension of the considerations, which enter into the successful application of this method or waterproofing, one must first have a knowledge as to the part the waterproofing compound itself is called upon to play. The whole system of Integral Waterproofing has been condemned in numerous instances because of the lack of understanding as to its exact function.

Without entering into the technique of the setting of cement, the attention is directed to that noteworthy feature of concrete, that even though of perfect proportioning and mixing, it contains innumerable minute voids in the form of hollows and ducts or channels, left by the inability of the particles to properly arrange themselves to secure an absolutely dense mass, and also by the evaporation of the excess of the gauging or tempering water. The larger of these pores can be seen with the naked eye, but the microscope reveals the actual porosity of any concrete specimen. These voids allow not only the infiltration of water when the concrete is under pressure, but their capillarity causes the water to be absorbed to a height, even greater than the water level outside the masonry.

It is the function of the Integral Compound to correct this inherent porosity of the Cement Product by filling these tiny voids or making negative their capillarity. It is a well-known fact that the sand should just fill the interstices of the stone or gravel and the cement should be at least sufficient in quantity to fill those of the sand. In turn the Waterproofing Compound is called upon merely to act upon the pores between the particles of the crystallized cement and sand and those within the cement content itself. ***It is not capable, however, of remedying any defects of construction or design, nor to correct improper and defective materials and workmanship***. The cement, sand and aggregate must fully perform their respective functions and this will obtain only in first class masonry. Abuse and condemnation have been heaped upon Integral Compounds where the fault lies entirely with the concrete work, and until the fundamental function of these compounds is universally appreciated as well as the necessity for fulfilling the conditions for obtaining good concrete, the real merit of Integral Waterproofing will not be fully asserted. Unless the masonry be first class in every respect it is a useless expenditure, and a detriment to the waterproofing industry to employ an Integral Material.

Dwelling briefly upon the essentials for good concrete, first, only proper materials should be used. Good cement costs no more ordinarily than cements of poor quality so this important component is generally all that is to be desired. As for the sand and gravel content, however, there is much room for comment. Particularly in outlying districts where the importation of these materials is an item of considerable expense, the importance of good, coarse, clean sand and gravel is often minimized and local

*Waterproofing Engineer, 101 Park Ave., N. Y. C.

materials used when they are entirely unfit. "Run of the bank" aggregate is often employed although there is almost invariably a large excess in sand, and to fill the sand voids and thus secure concrete of normal structural strength, it is necessary to incorporate an abnormal large quantity of cement. Besides the surplus of fine particles, "bank run" material usually contains a large percentage of loam, clay and other foreign materials deleterious to good concrete.

The proper proportioning and adequate mixing of the ingredients are of quite equal importance to their quality, all of which is obvious but often neglected. A lean mixture of concrete may be far superior to a rich one if the mixing of the ingredients be more thorough.

The amount of gauging water is also to be considered, and for best results as to density and also for strength, a mass of quaking consistency should be obtained. In field work, it is of course impossible to so regulate the water that all batches will be of like consistency and indeed this is not necessary. However, it should be borne in mind that mixtures too dry are porous as the particles fail to compact themselves from lack of lubrication, while the extremely wet mixtures are porous from the

VIEW No. 1.—Section of Retaining Wall Showing Leakage of Construction Joints. A Common Defect of Ordinary Concrete Work.

hollows left by the evaporation of the large excess of gauging water. It should, therefore, be the constant endeavor in Waterproofed Concrete work, to so regulate the water supply that the mass be as near "quaking consistency" as possible. For cement floor work, to secure maximum density and hardness the consistency should be such that a pailful of mortar will just retain its form when upended and pail removed. Concrete, however, should be deposited somewhat wetter than this.

The correct proportioning and thorough diffusion of the Waterproofing Compound also demands attention. Since the duty of this material relates to the cement voids the quantity to be used is a direct function of the cement content in the mortar or concrete. This statement appears paradoxical since theoretically more Waterproofing would be required for a lean mixture than for a rich one. However, the matter is clarified when it is remembered that the concrete itself must be of dense nature, the cement matrix being sufficient in quantity to completely fill the stone or gravel voids. Only the richer mixtures should be used, and for concrete subjected to hydrostatic pressure this should not be appreciably leaner than 1:2:4.

VIEW NO. 2

One Outlet for Water Removed from Foundation of Riverside Station, Elmira, N. Y., During Process of Construction

For maximum efficiency Waterproofing Compound should be added in quantity up to that point where a further increment would have a weakening effect upon the strength of the cement. The quantities advocated by the manufacturers of the materials are generally considerably less than the allowable maximum for economy's sake and to allow an ample margin of safety and it is advisable always to follow their directions in this regard. There is a general tendency to increase the quantity of the compound in the members subjected to the greatest pressure, but this is to be discouraged unless it be authoritatively ascertained that the allowable quantity limit is not thereby exceeded. Special care should be observed in the complete diffusion of the Compound throughout the mass as this is manifestly of equal importance to its correct proportioning. An excess of Waterproofing material in one section and a deficiency in another is of course a highly undesirable condition.

It is often maintained that if proper care be taken in the proportioning, mixing and placing of the ingredients, impervious concrete can be obtained without resorting to Integral Compounds, and indeed laboratory tests substantiate this assertion. However, in field operations where ideal conditions do not prevail, even the best concrete will allow the infiltration of water through portions at least, and comparative sections of concrete with and without a standard Integral Waterproofing Agent, will prove the fallacy of the assumption under working conditions.

The concrete should be carefully deposited in the forms—never dropped from a sufficient height to separate the ingredients. The mass should be well spaded, particularly those portions at the faces, so as to avoid honeycombing. ***All wooden spreaders and in fact wood of every description should be removed from the plastic mass.*** Not only is wood decidedly pervious but its swelling and subsequent warping if it come into contact with water, will cause internal stresses which may prove serious. All bolts and wire fastenings should be cut off at least an inch from the face of the concrete and the resultant holes pointed up.

Tight forms well braced are a prime requisite, as the cement water which is allowed to escape from loosely constructed and inadequately braced forms, contains the richest part of the strength-giving matrix.

A most important factor for Waterproofed Concrete and one perhaps most often neglected is the securing of a proper bond at the construction joints, vertically and horizontally, for unless due precautions be observed, these will develop planes of weakness. View No.1 illustrates a section of retaining wall of a bridge approach of a prominent western railroad. The seepage at the joints between the different days' work is a salient feature of the work, but indeed this fault is so general in ordinary concrete work of this nature that it creates but little attention. However in Waterproofed Concrete Work such faults must not exist for obvious reasons. At horizontal joints, laitance consisting of inert particles of cement and an excess of Waterproofing Compound collecting at the surface of concrete, must be removed and the surface scarified before new material is deposited upon it. The importance of this measure cannot be overestimated and yet its extreme necessity is rarely appreciated. After the removal of the bulk-heads the vertical surfaces should be thoroughly roughened (except in the case of expansion joints), preparatory to depositing the concrete in the adjoining section. For small structures or portions subjected to great pressure as pits, etc., the concrete work should be carried continuously to eliminate construction joints.

VIEW No. 3. Indicating Method of Controlling Water During Construction Work. Note the Wooden Box Drain at Outside of Concrete Floor Slab

Edison Illuminating Company, Detroit, Mich.
Hugh D. Gunnison, Architect
Built on marshy ground on the bank of the Detroit River. Basement effectively waterproofed against heavy hydrostatic pressure through the use of Trus-Con Waterproofing Paste, *Concentrated*

A consideration to which many failures in Waterproofed Concrete may be attributed is that relating to water-pressure existing during construction. An axiom for successful Integral Waterproofing is that *"Ground water, whether running or confined, must be kept away from the mass until final set has been attained."* If water under pressure be allowed to percolate through the plastic concrete, channels are formed and its efficieney as a Waterproofing Medium is destroyed. This principle is of great importance and to ignore it is to court trouble and inevitable failure. Ordinary concrete can be deposited under water often with very good results but not so with Waterproofed Concrete or Mortar. Water should not be permitted to come into contact with any part of the cement product until it is fully capable of resisting the pressure, and draining and pumping or bailing must be resorted to when necesary to fulfill this requirement. View No. 2 indicates the large quantity of water removed during the progress of construction of the Riverside Station at Elmira, N. Y. Two wooden stave pipes as outlets for the steam and electric pumps which operated continuously during the critical stages of construction, discharged upwards of 10,000,000 gallons of water per day.

When the quantity of ground water is considerable, the earth slope should be kept sufficiently outside the neat line of wall to permit the construction of a box or tile drain, (shown in View No. 3) or an open ditch at the level of lowest portion of Waterproofed masonry so that the water may be lead to a sump-pit thus relieving the pressure from the walls. Before the construction of the floor-slab a layer of gravel, broken stone or cinders 3 inches to 6 inches in thickness should be deposited for the dual purpose of allowing free access of the water to the sump-pit during the progress of work and for equalizing the pressure after the structure is completed. Sub-floor drains should be constructed, if necessary. In the case of heavy clay, or other impervious soils it not infrequently happens if the concrete be placed directly upon the earth that the pressure over one portion will be considerable while over another it may be nil. Therefore, in all cases where pressure exists or is likely to exist, a pressure equalizing medium as indicated should be installed.

Expansion joints are not ordinarily required for sub-terra work but for retaining walls, etc., exposed to extreme temperatures, they are a necessity. Copper flashing embedded in the adjoining sections of the masonry at the exterior face has been found very effective in rendering joints watertight, while a bituminous or rubber mastic spread by trowel over the vertical sections of concrete after the removal of the transverse bulkheads is very efficient in permitting the required expansion and contraction of the concrete.

Every section of a substructure should be carefully designed so that it will possess sufficient strength to resist all possible pressures and its foundation such as to preclude settlement. The Waterproofing can remain effective only so long as the bases remain in a sound and stable condition, and that this may obtain the substructure must act as a caisson in resisting the hydrostatic pressure while the structure itself must be able by weight to counteract the upward lifting force. The function of the Waterproofing is of course only to make the members impervious and not in any way to provide structural strength. This fact is often lost sight of, however, and futile attempts are not infrequently made to waterproof members not able to resist the pressure. A rupture in the wall or floor-slab is the result, and when such occurs only too often is the fault laid at the door of the Waterproofing System.

Briefly reviewing our discussion, the important considerations for the successful construction of Waterproofed Concrete may be summed up as follows:

1st. The ingredients for the concrete must be standard in every respect; the sand must be clean and coarse and the gravel or broken stone of best quality.

2nd. The Integral Compound must be of tested merit, incorporated in accordance with the manufacturer's directions and thoroughly diffused throughout the mass.

3rd. The ingredients must be so proportioned that the cement will completely fill the voids (of the sand and the matrix enter into all voids) of the aggregate. The mixing must be thorough so that all parts will be of uniform density, and a mass of "quaking consistency" should be secured.

4th. Tight forms well braced are an essential to good results. Care must be assumed in placing the concrete with particular attention to the spading at the faces and to the horizontal joints between the different days' work. No wood of whatsoever character should be allowed to remain in the concrete.

5th. Ground water must be kept from the mass until it is capable of resisting the destructive action of the water. Drainage and pumping must be resorted to when necessary.

6th. Each member of the structure must be so designed and constructed that the water pressure will be resisted without exceeding its structural strength. The foundation must be able to support the structure without excessive settlement, and the structure as a whole must possess sufficient weight to counter-act the lifting pressure.

If these fundamental conditions be fulfilled, good results are assured. Every unsuccessful case of Integral Waterpoofing in the past may be attributed to the lack of regard of one or more of these, while with their careful observance failure is impossible.

The Chalmers Motor Company, Detroit, Mich.
Albert Kahn, Architect
Trus-Con Waterproofing Paste, *Concentrated*, used in Concrete Work

The Trade Mark

This Trade-Mark, "The Sign of the Beacon Light," is placed on every package of TRUS-CON WATERPROOFING PASTE, Concentrated, be it a barrel of a five-gallon can.

It stands as a guarantee of quality and protects the purchaser against fraud and imitation.

The Trus-Con Laboratories

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